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# **Unexploded Ordnance Site Investigation of U.S. Military Ranges In Panama: Empire, Balboa West and Piña Ranges**

**FINAL REPORT**

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**PREPARED FOR:**

**PANAMA CANAL TREATY IMPLEMENTATION PLAN AGENCY**

**U.S. ARMY SOUTH**

**U.S. AIR FORCE INSTALLATION LOGISTICS ENVIRONMENTAL RESTORATION**

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## **EXECUTIVE SUMMARY**

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As part of the process of transferring the Empire, Balboa West, and Piña Ranges to the Government of Panama (GOP), the Panama Canal Treaty Implementation Plan Agency (TIPA), U.S. Army South (USARSO), and the U.S. Air Force Installation Logistics Environmental Restoration Office (USAF ILEVR) have funded and coordinated various unexploded ordnance (UXO) Site Investigation (SI) activities on the ranges in Panama. The purpose of the SI was to gather empirical ground data on certain areas of the Empire, Balboa West, and Piña Ranges to refine and/or confirm the conclusions made in the historical assessment of the ranges. The purpose of this report is to summarize the SI activities and to present the results in terms of refined UXO concentration maps.

Several organizations and agencies are involved in the range transfer process and have contributed data and/or input to this SI report including: TIPA, USARSO, Panama Canal Commission (PCC), U.S. Army Environmental Center (USAEC), Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV), U.S. Army National Guard Task Force 111 Explosive Ordnance Disposal (TF 111 EOD), U.S. Army Corps of Engineers (USACE), and USAF ILEVR. The roles and responsibilities of each organization and agency with respect to the SI effort and the range transfer process are listed in the report along with an appropriate point of contact. This report serves as a summary of SI activities including UXO clearance, characterization, and sampling activities and efforts conducted by the various organizations and agencies through the 18<sup>th</sup> of April 1998. It is important to note that several activities are still on going which may provide additional data that could change the assessments made in this report.

The intended use of this report is to provide all parties, including the GOP, involved in the range transfer process, a summary of the SI activities and data gathered with respect to UXO on the ranges as well as a current estimate of the condition of each area of concern with respect to UXO concentrations. This report does not propose range transfer activities or suggests any policy guidance related to the turnover of Empire, Balboa West and Piña Ranges.

This SI report has three major components including: the approaches and methodologies employed to collect data; the data collected during the SI, and the analysis of the data in terms of updated UXO

concentration maps. For background, the following sections are also included in this report: UXO Concentrations, UXO Process, UXO Detection Technologies, and UXO Detector Reference Area.

The results of the historical archive research effort conducted for the Empire, Balboa West and Piña Ranges in Panama can be found in the report entitled: *Unexploded Ordnance Assessment of U.S. Military Ranges in Panama: Empire, Balboa West, and Piña Ranges* (NAVEODTECHDIV) 1997a. The UXO Assessment Report identified and characterized range areas in Panama with respect to potential UXO concentrations. The report classified areas as either an UXO Area of Concern (UXO AOC), suspected UXO AOC, or an area of interest. UXO AOC's are areas that most likely contain UXO based on range activities and/or range records. The report used a 5 tier relative scale to qualitatively evaluate each UXO AOC with respect to UXO concentration levels. Suspect UXO AOCs are areas that did not have direct evidence indicating that they contained UXO, instead indirect evidence or anecdotal information suggested that UXO may be present. Areas of interest are areas where insufficient information was available to formulate conclusions regarding UXO concentrations or because UXO concentrations are unlikely. Suspect UXO AOCs and areas of interest were not evaluated in terms of the relative UXO concentration scale because insufficient information was available to formulate conclusions regarding UXO concentrations or because UXO concentrations were unlikely. Although the relative UXO classification system is valid for defining general UXO concentrations it does not specifically discriminate between surface and subsurface UXO concentrations. To fully describe UXO concentrations a depth component must be considered.

The depth to which ordnance concentrations may exist depends upon the maximum penetration depths for the particular ordnance types in question. Ordnance penetration depths depend upon the characteristics of the impacting ordnance item and the soil or medium in which the item is impacting into. The ordnance characteristics, which effect penetration depth, include the ordnance weight, shape, material, velocity, and angle of impact (entry). The results of a study conducted by the U.S. Army Corps of Engineers Waterways Experiment station (WES) published in an U.S. Army Technical Manual (TM) entitled *Fundamentals of Protective Design For Conventional Weapons*, TM 5-855-1 (U.S. Army 1986) was used to estimate the maximum penetration depths. The results are presented in the report and cover the majority of the ground deployed ordnance items used in Panama based on the initial UXO Assessment report.

DoD has been dealing with ranges and training areas containing UXO for many years and has developed procedures, guidelines and processes for areas containing UXO. The typical process treating areas containing UXO hazards involves several phases including; a historical assessment of the ranges, a SI or on site sampling phase, an Engineering Evaluation (EE) of potential technologies, a range transfer plan, an end use plan, and an explosive safety submission. Panama is special case because a Treaty governs the transfer of range properties therefore, successful turnover or transfer of range properties in Panama involves a combination of the UXO process plus Treaty obligations. The historical assessment has been completed for Panama and this report herewith covers the SI portion of the process. The EE of technologies, the range transfer plan and explosive safety submission are all forthcoming. A description of each step in the typical DoD process in dealing with UXO concentration areas is included in the report.

UXO Detection technologies for use in Panama were examined and evaluated in the January 1997 report entitled "Evaluation of Unexploded Ordnance Detection and Interrogation Technologies For Use in Panama: Empire, Balboa West and Piña Ranges". UXO detection refers to locating and potentially identifying surface and subsurface anomalies. This preliminary evaluation of UXO detection and interrogation technologies for use on the Empire, Balboa West, and Piña Ranges in Panama focused on the effectiveness and implementability of the technologies. Five categories of UXO detection sensors were evaluated in that report: passive magnetometry, active electromagnetic (EM) induction, ground-penetrating radar (GPR), infrared (IR), and a multisensor approach (which is a combination of the other four sensor types). UXO detection sensors were further evaluated according to the following operational platforms: airborne, vehicle-towed, and man-portable.

The preliminary technology evaluation was used to select the detection technologies and platforms used for employing these technologies for the SI effort. Two categories of technologies, GPR, and IR were ruled out from the start. The three remaining categories that were promising included: passive magnetometry, active EM induction, and a multi-sensor approach. Two specific technologies from the first category, passive magnetometry, were selected for the SI: a cesium vapor magnetometer system using a Geometrics™ G858 magnetometer and the Schonstedt™ magnetic locator. One active EM system was used; the Geonics™ EM61 time domain metal detector. The third category, multi-sensor approach, was obtained by using technologies from the passive magnetometry and EM system categories together. In addition, from the initial preliminary evaluation results, it was concluded that airborne detection platforms would not be effective in Panama. The preliminary report also assessed that vehicle-towed UXO detection systems would be effective and implementable in areas on the ranges that are

currently accessible to vehicles, or that would be accessible with limited road construction. The preliminary assessment concluded that man-portable UXO detection systems would be effective and implementable in many areas of the ranges in Panama, but not in steeply sloping or very densely vegetated areas, which would severely hinder the employment of any UXO detection technology. Only man-portable UXO detection platforms were used during the SI effort in Panama. A description of each technology category along with the specific sensors selected from each category and method of employment is presented in the report.

To meet the objectives of the SI for the ranges in Panama a couple of sampling techniques, methodologies and statistical tools were used including transect sampling, and random grid sampling. Transect sampling involves sampling a random slice of an area where density values are expected to change during the progression of the transect. Random grid sampling involves marking discrete grids of random size and placement throughout an area of concern and sampling those grided areas for UXO concentrations. A description of the methodology and process for transect and grid sampling is included in the report. In addition to the UXO sampling efforts this SI report also includes various range clearance and Range Policing activities that were conducted on the Empire, Balboa West and Piña Ranges. All the information gained from each SI activity and sampling methodology has been combined in this report to provide an overview of the activities and the results in terms of the potential UXO concentrations levels for the Empire, Balboa West, and Piña Ranges in Panama.

Prior to using the technologies to collect data the detectors were evaluated on a detector reference area. A detector reference area is an area designated for evaluating ordnance detectors in a controlled condition in an environment similar to where the detectors are to be utilized. An area of the range that has not been used in the past for ordnance testing and does not contain UXO or ordnance related debris was selected and known targets, similar to the ones expected to be found on the actual survey areas, were buried at detectable depths. The sensors were then used to survey the area to determine if the controlled targets could be found.

The purpose was to assess the subsurface detectors operating performance on a known area, prior to implementing the technology in the field. This assures that the technologies do indeed work in the intended environment and provides a gauge for the capabilities and limitations of the detectors in the target environment. Many environmental factors affect the performance of the sensor including background noise associated with the local environment. Some instruments offer sensor settings that can be used to compensate for background noise levels. The reference area, therefore, also served as an area

where subsurface detection equipment was fine-tuned to local environmental conditions. A description of the reference area layout and targets is presented in the report along with a summary of the performance of the detectors used there.

Once it was determined that the technologies can perform in the environment (see EE report for detailed evaluation) the detectors were used on various portions of the Empire, Balboa West and Piña Ranges to collect sub-surface anomaly data. Other areas were surface swept for UXO or policed of range debris and UXO and were not sub-surface characterized.

Areas visited during the SI on the Empire Range included: the Main Impact Area, Range 6, Range 1/1A Area, EOD Range, Firing Fans Associated with Range 19, Range 18, the Firing Fan Areas associated with Firing Points (FP) 11 and 15, Camp Bayonet, Suspect Rio Fuentes Washout Area, Suspect Range 6 Impact Area, the Tire House Complex, Training Area 42(42) Old Ammunition Depot, and TA 49 Observation Point 4.

Areas visited during the SI on the Balboa West Range included: Tactical Targets 1-8 (TTs 1-8), Live Ordnance Area B (LO-B), the Suspect Army-Navy Bombing Area, the Suspect Army Ground Ordnance Area, the Suspect Area Outside TT-8 Bombing Pattern, and the Suspect Area Outside LO-A Bombing Pattern.

Areas visited during the SI on the Piña Range included: the Piña Multipurpose Range, the Piña Live Fire Village and Access Road, the Piña Demolition Range and the Suspect Piña 1960's Impact Area.

For each area visited during the SI the activities conducted, results, and conclusions are presented in the report along with the background information from the historical study for comparison. From the results and conclusions of the individual areas visited a refined UXO concentration map was generated for the Empire, Balboa West and Piña Ranges and is presented in the report. Table ES-1 presents the summary of the range lands (in hectares) with respect to UXO concentration levels.

**Table ES-1 Hectares With Indicated UXO Density**

<b>Range</b>	<b>Hectares with Indicated UXO Density</b>							<b>Total Range Area</b>
	<b>No Evidence</b>	<b>Very-High</b>	<b>High</b>	<b>Med</b>	<b>Low</b>	<b>Very-Low</b>	<b>Suspected</b>	
Empire	4,547	68.7	363.1	106.9	700.7	727.6	0	6,514
Balboa West	304.6	31	516	718	0	0	2,130.4	3,700
Piña / Ft. Sherman	7,788.6	3.4	154	1,175.0	362.0	233.0	0	9,716

The values presented in Table ES-1 represents a snapshot in time of the current conditions of the Ranges and Training Area with respect to UXO concentrations. As UXO removal and sampling operations continue on the ranges the UXO assessments will change.

## **1.0 INTRODUCTION**

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As part of the process of transferring the Empire, Balboa West, and Piña Ranges to the Government of Panama (GOP), the Panama Canal Treaty Implementation Plan Agency (TIPA), U.S. Army South (USARSO), and the U.S. Air Force Installation Logistics Environmental Restoration Office (USAF ILEVR) have funded and coordinated various Site Investigation (SI) activities on the ranges in Panama.

### **1.1 Purpose**

The purpose of this report is to summarize those SI activities conducted by the different organizations involved in the SI efforts to date and to refine and/or confirm the conditions of the Empire, Balboa West and Piña Ranges, with respect to potential unexploded ordnance (UXO) concentration levels.

### **1.2 Background**

Subsequent to and in accordance with the Panama Canal Treaty of 1977, the U.S. Department of Defense (DoD) issued policy guidance for the transfer of DoD installations to the GOP. The required documentation includes an Installations Condition Report (ICR) that identifies known hazards to human health and safety. USARSO was responsible for preparing the ICR for the Empire and Piña Ranges, while the Air Force was responsible for the Balboa West Range.

To support the ICR for Empire, Balboa West, and Piña Ranges, TIPA tasked the U.S. Army Environmental Center (USAEC) and the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) to conduct a UXO assessment of the three ranges in Panama. The results of this assessment were included in two reports: 1) "Unexploded Ordnance Assessment of U.S. Military Ranges in Panama: Empire, Balboa West, and Piña Ranges", dated January 1997 (hereinafter called the UXO Assessment Report) and 2) "Evaluation of Unexploded Ordnance Detection and Interrogation Technologies For Use In Panama: Empire, Balboa West and Piña Ranges", dated January 1997. The UXO Assessment report identified and characterized range areas in Panama with respect to potential UXO concentrations based on historical records and findings. The UXO assessment report used a five-tier qualitative UXO concentration scale to relatively evaluate UXO areas of concern (UXO AOCs) in the three ranges in Panama. The five-tier classification scale was as follows: very-high, high, medium, low, and very-low. In addition to the UXO AOCs the report also defined three additional types of areas: suspect UXO AOCs, area of interest, and areas with no evidence of UXO concentrations. Suspect areas

were defined as areas that did not have direct evidence indicating that they contained UXO; instead indirect evidence or anecdotal information suggested that UXO may be present. Areas of interest are areas where insufficient information was available to formulate conclusions regarding UXO concentrations or because UXO concentrations are unlikely.

As with any study based solely on a record search there exists a certain amount of uncertainty associated with the data because of the lack of field data to verify the conclusions. As a result, TIPA, USARSO, and USAF ILEVR have coordinated a SI effort which included UXO characterizations, UXO sampling, and UXO clearance operations on various portions of the Empire, Balboa West, and Piña Ranges. All SI activities conducted on the ranges are part of an orchestrated effort of several organizations and agencies all working toward the ultimate goal of transferring the ranges to the GOP in accordance with the Treaty and applicable DoD policies.

In addition to the effort coordinated by TIPA, USARSO, and USAF ILEVR, the Panama Canal Commission (PCC) has been working on a plan to widen and add another set of locks to the canal. The plan involves the following types of UXO related activities to be conducted on various portions of the Empire Range potentially affected by the PCC plan including surface clearance, limited subsurface clearance, on-site characterizations, and sampling for UXO concentrations. Since that on-going effort involves UXO related activities and provides valuable information for the Empire Range, the data from that effort was incorporated into the SI to provide a summary of all UXO related activities conducted to date on the ranges. The overall goal of the SI is to refine and/or confirm the UXO concentration evaluations for the Empire, Balboa West and Piña Ranges.

### **1.3 Organizations**

Several organizations and agencies are involved in the range transfer process and have contributed data and/or input to this SI report including: TIPA, USARSO, NAVEODTECHDIV, U.S. Army National Guard Task Force 111 Explosive Ordnance Disposal (TF 111 EOD), U.S. Army Corps of Engineers (USACE), U.S. Southern Command Center for Treaty Implementation (SCTI), and USAF ILEVR. The roles and responsibilities of each organization and agency with respect to the SI effort and the range transfer process are listed below. A point of contact for each organization can be found in Appendix A.

### **1.3.1 Panama Canal Treaty Implementation Plan Agency (TIPA)**

TIPA has the overall responsibility of overseeing the implementation of the Panama Canal Treaty of 1977. As part of their responsibilities, TIPA performs the following duties: acts as the focal point for service components on treaty related issues; coordinates communication between stateside agencies and organizations, U.S. operations in the Panama Canal Area, and the GOP; and identifies, tracks, and manages transfer issues.

### **1.3.2 U.S. Army South (USARSO)**

USARSO is the lead DoD service in the Southern Hemisphere and is responsible for the overall condition of the ranges and training areas prior to the transfer of the properties to the GOP. They are responsible for ensuring the range transfer plans have the proper approval and the plans are followed to meet the obligations set forth in the Panama Canal Treaty. USARSO works directly with the USAF and TIPA on environmental issues related to transfer of properties. USARSO has an active duty Explosive Ordnance Disposal (EOD) unit, the 786<sup>th</sup> Ordnance Company (EOD), who participated in the SI by providing EOD support for certain range activities.

### **1.3.3 Panama Canal Commission (PCC)**

The PCC manages the operation and maintenance of the Canal and it's surrounding watersheds. They control the land in the canal-operating zone and are responsible for several canal enhancement projects including the on going widening effort and the proposed third lock plan (see Map 1-1). The current widening and third lock plans call for spoil material to be dumped on several portions of the Empire Range that are currently characterized as UXO AOCs. The plan for the proposed third locks show, the path of the locks cutting through a portion of the Empire Range Main Impact Area. Because of this the PCC has tasked the USACE to conduct UXO sampling and surveys on portions of the area effected by the plan. The PCC works with USARSO and TIPA on issues relating to PCC property which is currently being used by DoD.

### **1.3.4 U.S. Army Environmental Center (USAEC)**

USAEC from Aberdeen, Maryland is responsible for various environmental programs throughout the DoD including projects related to the restoration of DoD installations. USAEC worked directly with NAVEODTECHDIV under tasking from TIPA, USARSO, and USAF ILEVR to conduct UXO surveys

and sampling in very-low and suspect UXO concentration areas as defined in the UXO Assessment report. USAEC acted as the program manager for the SI activities including developing and overseeing the Range reports. USAEC and NAVEODTECHDIV were both responsible for producing this SI report.

### **1.3.5 Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV)**

NAVEODTECHDIV from Indian Head, Maryland is a joint service organization that is responsible for operating and managing the EOD school for all EOD personnel in the military. NAVEODTECHDIV worked directly with USAEC under tasking from TIPA, USARSO, and USAF ILEVR to conduct UXO surveys and sampling in very-low and suspect UXO concentration areas as defined in the UXO Assessment report. Responsibilities also included collecting data from the various organizations involved in the SI effort and formalizing this report.

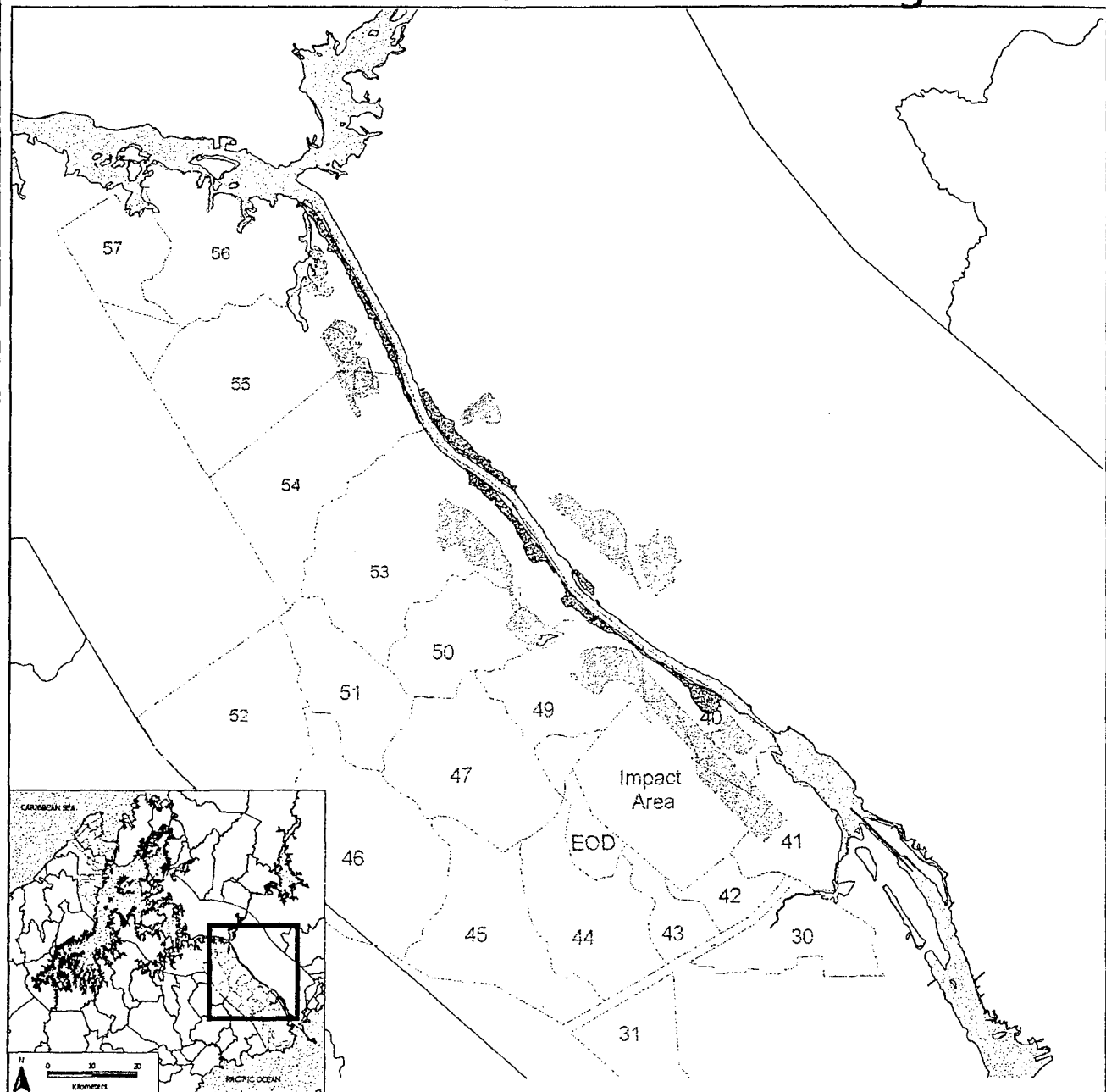
### **1.3.6 U.S. Army National Guard Task Force 111 EOD (TF 111 EOD)**

TF 111 EOD from Huntsville, Alabama is a USARSO sponsored organization comprised of National Guard and Active Duty EOD soldiers. TF 111 was tasked by USARSO to conduct range clearance and/or range characterization operations on select areas of the Empire and Piña Ranges. TF 111 EOD was supported by several EOD units including: the 786<sup>th</sup> ordnance company (EOD) unit from Panama, 111<sup>th</sup> Ordnance Group, 669<sup>th</sup> Ordnance Detachment, 221<sup>st</sup> Ordnance Detachment, 363<sup>rd</sup> Ordnance Detachment, 666<sup>th</sup> Ordnance Detachment, 745<sup>th</sup> Ordnance Detachment, and various National Guard assets who provided personnel and equipment to assist in their portion of the SI effort.

### **1.3.7 U.S Army Corps of Engineers (USACE)**

USACE from Huntsville, Alabama is the lead agency responsible for the management of clean-up activities of ordnance and explosive waste (OEW) from DoD formerly used defense sites (FUDS). USACE was tasked by the PCC to conduct a range sampling effort on the portions of the Empire Main Impact Area that will potentially be affected by the canal widening and planned third lock projects.

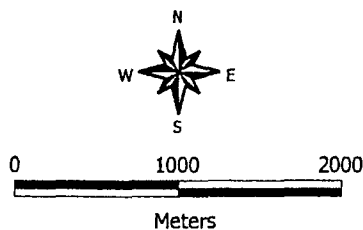
# Canal Third Locks and Widening



## Legend

- Training Areas
- Canal Widening
- Disposal Area (Planned)
- Disposal Area (Used)
- Excavation Area
- Area Affected by Third Set of Locks

Map Not To Scale



Source: Army Corps of Engineers

Map 1-1 Canal Third Locks And Widening

### **1.3.8 U.S. Southern Command Center for Treaty Implementation (SCTI)**

SCTI heads the U.S. component of the Treaty mandated Joint Committee and performs Treaty implementation functions for the responsible Commander in Chief (CINC). SCTI has provided guidance and insight during the SI effort.

### **1.3.9 United States Air Force Installation Logistics Environmental Restoration (USAF ILEVR)**

USAF ILEVR from Alexandria, VA coordinates USAF efforts related to the environment and USAF installations. The USAF ILEVR coordinated with the USAF Air Combat Command (USAF ACC) from Langley, VA, who are the command and control center for the USAF on issues regarding the ranges and training areas owned or leased by the USAF. USAF ACC coordinated clearance operations on the Balboa West Bombing Range by utilizing USAF assets including the 24<sup>th</sup> EOD Unit in Panama and various USAF Technical Laboratories throughout the world. USAF ILEVR works directly with USAF commanders in Panama, USARSO, and TIPA on issues related to the transfer of properties under the Treaty.

## **1.4 Project Goals**

The goals of this report are to summarize the various SI activities conducted by the different organizations listed above and to refine and/or confirm the UXO concentration estimates for the Empire, Balboa West and Piña Ranges based on empirical ground data gathered. The SI effort provides field data collected from various areas of concern on the Empire, Balboa West, and Piña Ranges. The field data reduces the amount of uncertainty in the original findings while refining, and/or confirming the original UXO characterization of certain other areas with respect to the UXO concentration levels in the UXO Assessment report.

The scope of this SI report covers the various efforts through the 18<sup>th</sup> of April 1998. It is important to note that several activities are still on going which may provide additional data that could change the assessments made in this report.

The intended use of this report is to provide all parties, including the GOP, involved in the range transfer process, a summary of the SI activities and data gathered as well as a current estimate of the condition of the ranges with respect to UXO concentrations. This report does not propose range transfer activities or suggests any policy guidance related to the turnover of Empire, Balboa West and Piña Ranges.

## **1.5 Report Organization**

This SI report has three major components including: the approaches and methodologies employed to collect data; the data collected during the SI, and the analysis of the data in terms of updated UXO concentration maps. Table 1-1 outlines the report with respect to the three major components and provides the corresponding section numbers. For background, the following sections are also included in this report: UXO Concentrations, UXO Process, UXO Detection Technologies, and Detector Reference Area.

**Table 1-1 UXO Site Investigation Report Components**

<b>UXO Site Investigation Component</b>	<b>Section</b>
Site Investigation Approach	5.0
Site Investigation Empire Range	8.0
Site Investigation Balboa West Range	9.0
Site Investigation Piña Range	10.0
Revised UXO Concentrations	11.0

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Piña and Balboa West Ranges*

## 2.0 UXO CONCENTRATIONS

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Results of the historical archive research effort conducted for the Empire, Balboa West and Piña Ranges in Panama can be found in the UXO Assessment Report. The UXO Assessment Report identified and characterized range areas in Panama with respect to potential UXO concentrations. The report classified areas as either a UXO AOC, suspect UXO AOC, an area of interest, or an area with no evidence of UXO concentration. UXO AOCs are areas that most likely contain UXO based on range activities and/or range records. The report used a five-tier qualitative UXO concentration scale to relatively evaluate UXO AOCs in the three range areas in Panama. The UXO concentrations were as follows: very-high, high, medium, low, and very-low. Suspect areas were defined as areas that did not have direct evidence indicating that they contained UXO; instead indirect evidence or anecdotal information suggests that UXO may be present. Areas of interest are areas where insufficient information was available to formulate conclusions regarding UXO concentrations or because UXO concentrations are unlikely. Although the classification system is valid for defining general UXO concentrations it does not specifically discriminate between surface and subsurface UXO concentrations.

### 2.1 Surface vs. Subsurface UXO Concentrations

UXO concentrations are actually 3-dimensional, in order to fully describe UXO concentrations a depth component must be added to the longitude and latitude components. Ordnance penetration depths depend upon characteristics of the ordnance item deployed and the properties of the soil being impacted. The major characteristics that effect penetration depth include ordnance weight, shape, material, velocity, and angle of impact into the soil. Studies have been conducted over the years on ordnance penetration depths vs. soil conditions. An extensive study which offers generalized solutions and produces estimates for maximum expected UXO penetration depths was developed by the Soils Dynamics Laboratory at the U.S. Army Corps of Engineers Waterways Experiment Station (WES). The results of the study have been published in an U.S. Army Technical Manual (TM) entitled *Fundamentals of Protective Design For Conventional Weapons*, TM 5-855-1. The theory and formulas derived from TM 5-855-1 have also been incorporated into a software program which has the capability of estimating the maximum theoretical depth of penetration of ordnance items based upon the factors listed above.

The theories and formulas derived in TM 5-855-1 are not presented here but the results are. The maximum penetration depths are presented in Table 2-1 and cover the majority of the ground deployed ordnance items used in Panama based on the initial UXO Assessment report.

The safe earth fill is also included in Table 2-1 which, represents the minimum amount of overburden (thickness) that is required to contain an explosion from that particular ordnance type. If an explosion were to occur beneath the ground at a depth equal to or greater a the safe earth fill thickness the explosion would not effect the surface. The safe earth thickness values are covered further in Section 8.3 of this report which discusses the area formally known as Range 6 where the spoil material from the Gaillard Cut widening project is being dumped.

Table 2-1 UXO Penetration Depths

Ordnance Type	Gross Ordnance Weight		Estimated Maximum UXO Penetration				Safe Earth Fill (overlay thickness)		Explosive Weight		Ordnance Body Weight	
			sandy soil		clayey soil							
	lbs.	kgs.	feet	meters	feet	meters	feet	meters	lbs.	kgs.	lbs.	kgs.
20mm	0.56	0.25	1.0	0.305	3.0	0.914	0.9	0.274	0.29	0.13	0.56	0.25
60mm	3.52	1.60	1.0	0.305	3.0	0.914	2.6	0.792	0.42	0.19	3.52	1.60
2.36"	19.40	8.81	1.0	0.305	3.0	0.914	2.8	0.853	1.82	0.83	19.40	8.81
66mm	2.35	1.07	2.0	0.610	4.5	1.372	3.1	0.945	0.67	0.30	2.35	1.07
37mm	1.61	0.73	2.5	0.762	6.0	1.824	2.6	0.792	0.11	0.05	1.61	0.73
40mm (AA)	1.98	0.90	2.5	0.762	6.5	1.976	1.8	0.549	0.14	0.06	1.98	0.90
81mm	9.22	4.19	3.0	0.914	6.5	1.981	5.7	1.737	2.05	0.93	9.22	4.19
2.75" rocket	8.90	4.04	3.5	1.067	7.5	2.286	6.0	1.829	2.32	1.05	8.90	4.04
57mm	5.29	2.40	4.0	1.219	8.5	2.591	2.9	0.884	0.55	0.25	5.29	2.40
4.2" mortar	27.07	12.29	4.0	1.219	8.5	2.591	6.9	2.103	7.80	3.54	27.07	12.29
75mm	10.14	4.60	4.5	1.372	9.5	2.896	4.8	1.463	1.49	0.68	10.14	4.60
105mm	31.80	14.44	5.5	1.676	11.5	3.505	6.9	2.103	5.08	2.31	31.80	14.44
106mm recoilless	17.55	7.97	5.5	1.676	10.5	3.200	6.9	2.103	7.72	3.50	17.55	7.97
3.5"	9.00	4.09	5.5	1.676	10.5	3.200	4.3	1.311	1.88	0.85	9.00	4.09
76mm	14.15	6.42	6.0	1.829	12.0	3.658	4.0	1.219	1.46	0.66	14.15	6.42
3"	13.50	6.13	6.0	1.829	12.0	3.658	3.5	1.067	0.74	0.34	13.50	6.13
4.5"	42.50	19.30	6.5	1.981	13.0	3.962	6.4	1.951	4.30	1.95	42.50	19.30
90mm	11.24	5.10	7.0	2.134	13.0	3.962	4.5	1.372	2.15	0.98	11.24	5.10
152mm	95.92	43.55	7.5	2.286	16.0	4.872	6.5	1.981	9.50	4.31	95.92	43.55
5"	70.00	31.78	8.0	2.438	16.5	5.029	8.3	2.530	7.59	3.45	70.00	31.78
155mm	94.60	42.95	8.5	2.591	16.5	5.029	8.7	2.652	15.40	6.99	79.20	35.96
120mm	31.20	14.16	9.0	2.743	17.0	5.182	7.0	2.134	6.59	2.99	31.20	14.16

The above table provides an estimate on the maximum ordnance penetration depth for various ordnance items common to Panama. The Panama soil is mostly clayey therefore the maximum probable ordnance penetration depths that apply to Panama are found in the clayey soil column which is highlighted. This data is useful to determine the potential maximum extent of UXO concentrations in terms of depth for

## 2.0 UXO CONCENTRATIONS

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Results of the historical archive research effort conducted for the Empire, Balboa West and Piña Ranges in Panama can be found in the UXO Assessment Report. The UXO Assessment Report identified and characterized range areas in Panama with respect to potential UXO concentrations. The report classified areas as either a UXO AOC, suspect UXO AOC, an area of interest, or an area with no evidence of UXO concentration. UXO AOCs are areas that most likely contain UXO based on range activities and/or range records. The report used a five-tier qualitative UXO concentration scale to relatively evaluate UXO AOCs in the three range areas in Panama. The UXO concentrations were as follows: very-high, high, medium, low, and very-low. Suspect areas were defined as areas that did not have direct evidence indicating that they contained UXO; instead indirect evidence or anecdotal information suggests that UXO may be present. Areas of interest are areas where insufficient information was available to formulate conclusions regarding UXO concentrations or because UXO concentrations are unlikely. Although the classification system is valid for defining general UXO concentrations it does not specifically discriminate between surface and subsurface UXO concentrations.

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The theories and formulas derived in TM 5-855-1 are not presented here but the results are. The maximum penetration depths are presented in Table 2-1 and cover the majority of the ground deployed ordnance items used in Panama based on the initial UXO Assessment report.

The safe earth fill is also included in Table 2-1 which, represents the minimum amount of overburden (thickness) that is required to contain an explosion from that particular ordnance type. If an explosion were to occur beneath the ground at a depth equal to or greater a the safe earth fill thickness the explosion would not effect the surface. The safe earth thickness values are covered further in Section 8.3 of this report which discusses the area formally known as Range 6 where the spoil material from the Gaillard Cut widening project is being dumped.

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76mm	14.15	6.42	6.0	1.829	12.0	3.658	4.0	1.219	1.46	0.66	14.15	6.42
3"	13.50	6.13	6.0	1.829	12.0	3.658	3.5	1.067	0.74	0.34	13.50	6.13
4.5"	42.50	19.30	6.5	1.981	13.0	3.962	6.4	1.951	4.30	1.95	42.50	19.30
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152mm	95.92	43.55	7.5	2.286	15.0	4.572	6.5	1.981	9.50	4.31	95.92	43.55
5"	70.00	31.78	8.0	2.438	16.5	5.029	8.3	2.530	7.59	3.45	70.00	31.78
155mm	94.60	42.95	8.5	2.591	16.5	5.029	8.7	2.652	15.40	6.99	79.20	35.96
120mm	31.20	14.16	9.0	2.743	17.0	5.182	7.0	2.134	6.59	2.99	31.20	14.16

The above table provides an estimate on the maximum ordnance penetration depth for various ordnance items common to Panama. The Panama soil is mostly clayey therefore the maximum probable ordnance penetration depths that apply to Panama are found in the clayey soil column which is highlighted. This data is useful to determine the potential maximum extent of UXO concentrations in terms of depth for

particular ordnance types. The maximum penetration depths add the third spatial component needed to define UXO concentrations in forms of 3D. In theory UXO can be found on the ranges up to their maximum depths of penetration.

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Piña and Balboa West Ranges*

### **3.0 UXO PROCESS**

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DoD has been dealing with ranges and training areas containing UXO for many years and has developed procedures, guidelines and processes for dealing with areas containing UXO. The typical process in dealing with areas containing UXO hazards involves several phases including; a historical assessment phase, a site investigation or sampling phase, an Engineering Evaluation (EE) of potential technologies phase, a range transfer plan, an end use plan, and an explosive safety submission. Panama is a special situation because a Treaty governs the transfer of the range properties; therefore, successful turnover or transfer of range properties in Panama involves a combination of the UXO process plus Treaty obligations. The historical assessment was completed for Panama in 1997, this report pertains to the SI portion of the process. The EE of technologies, range transfer plans and explosive safety submissions are all forthcoming. A description of each step in the typical UXO process is included below.

#### **3.1 Steps / Procedure**

The first step to take in dealing with lands that potentially contain UXO is to conduct a historical study of the ranges to determine what ordnance types and concentrations may be found on the ranges. Because range boundaries tend to shift over the years due to training needs and weapon safety considerations, it is important to track the layout of the areas as far back in time as possible. A historical study errs on the conservative side listing as much information about the area as possible. The historical study becomes a guide for planning future activities on the ranges to ensure a successful transfer or turn over. The historical archive study for the Empire, Balboa West and Piña Ranges was conducted in 1996 and finalized in January of 1997. The report is entitled "Unexploded Ordnance Assessment of U.S. Military Ranges in Panama: Empire, Balboa West and Piña Ranges".

Although the historical study is based on past records there is a certain amount of uncertainty associated with the results due to data gaps, suspect areas and unconfirmed data. To minimize the amount of uncertainty in the initial reports a SI effort was undertaken. The SI effort involved on site sampling to refine or verify the conclusions made in the original assessment and to provide ground truth data that reduces the amount of uncertainty associated with the areas. The results of the UXO characterization and sampling efforts are used to refine the UXO concentration levels and boundaries. Certain areas show an increase in terms of potential UXO concentration levels while others show a reduction in the UXO concentration levels, as compared to the initial historical assessment, based on results of the sampling

data. This report covers the SI step of the UXO process and refines the UXO concentration assessments for the Empire, Balboa West and Piña Ranges.

The third phase of the UXO process involves testing and evaluating potential UXO detection and interrogation technologies on site to determine the capabilities and limitations of each technology. UXO detection and interrogation technologies were initially identified in the January 1997 report, "Evaluation of Unexploded Ordnance Detection and Interrogation Technologies For Use in Panama: Empire, Balboa West and Piña Ranges". The report covered general families of detection and interrogation technologies and listed the ones that are potentially applicable to Panama. From the conclusions of that report specific technologies from the potentially applicable technology families were selected for the EE. The EE effort takes a detailed look at specific technologies, their performance, operation and applicability in the Panamanian environment. The results of the EE will be published in a separate report entitled "Engineering Evaluation of UXO Detection and Interrogation Technologies for use in Panama: Empire, Balboa West and Piña Ranges". There report can be used as a guide for determining how and where technologies can potentially be used and what consequences and results can be expected from implementing such technologies.

The SI and EE reports are to be used as guidance for the fourth step in the process; finalizing the range transfer plan and explosive safety submission for the ranges. The range transfer plan lists the activities to be conducted at each area of concern and provides rational for those decisions in order to ensure the areas are in compliance with the Treaty and DoD policy. The range transfer plan will include a summary of the range areas and UXO hazard. This summary along with the factors affecting UXO clearance, will provide a guide for end use options in terms of depth of clearance for each area of concern. The U.S. clearance depths and end land use guidelines are covered in the Department of Defense Explosive Safety Board's (DDESB) standard entitled "DoD Ammunition and Explosives Safety Standards", (DoD Standard 6055.9), the standard provides general guidance for the clearance depths in terms of potential land usage. Table 3-1 lists the end land uses and corresponding clearance depths covered in DoD Standard 6055.9.

**Table 3-1 DDESB Standard 6055.9 Planned End Land Use And Clearance Depth**

<b>PLANNED END USE</b>	<b>CLEARANCE DEPTH</b>
<b>Unrestricted</b> Commercial / Residential / Subsurface Recreational Activity	3.04 meters (10 Feet)
<b>Public Access</b> Farming / Agriculture / Vehicle Parking / Surface Supply Storage	1.22 meters (4 Feet)
<b>Limited Public Access</b> Livestock Grazing / Wildlife Preserve	.3048 meters (1 Foot)
<b>Not Yet Determined</b>	Surface
<b>Like Use</b> (Remediation will be consistent with Service regulations concerning routine maintenance of impact areas).	

The explosive safety submission is a separate plan that covers how the range transfer plan is to be conducted to ensure that all clearance activities are in compliance with proper safety procedures and standards for explosive operations. The range transfer plan and site safety submission are forthcoming documents that will be issued through USARSO for the Empire and Piña Ranges and the USAF for the Balboa West Range.

The final step is to implement the plans to meet the goals of transfer in accordance with the Panama Canal Treaty of 1977, and applicable U.S. DoD issued policy. These plans will be carried out in the 1999 dry season. USARSO is responsible for ensuring that the plan is executed in an effective and timely manner for the Empire and Piña Ranges. USAF is responsible for executing the range transfer plan for Balboa West in an effective and timely manner.

### **3.2 Site Investigation Process**

Since this report covers the SI phase of the UXO process, it is important to cover in further detail what is involved in the SI phase of the UXO process. The SI involves sampling specific areas of Empire, Balboa West and Piña Ranges for UXO concentration levels. The areas were selected based upon their preliminary characteristics presented in the UXO Assessment report. Different sampling techniques and

approaches were used depending upon the area sampled. The sampling techniques and methodologies used are covered in Section 5.0 of this report. The areas were either surveyed for surface or surface and subsurface UXO concentrations. A description of both surface and subsurface sampling is provided below.

### **3.2.1 SI Surface Survey**

The surface survey involved visually inspecting and clearing the specific sampling areas of all UXO and ordnance related scrap from the surface of the area. In order to safely enter an impact area to surface clear UXO, it is necessary to remove the vegetation and overgrowth. Due to the environment in Panama the vegetation and overgrowth removal process was difficult and time consuming. Several methodologies of vegetation removal were used including burning, manually cutting, and mechanized grass cutters. Figure 3-1 shows an area that has been burned to clear the vegetation and overgrowth. The surface surveyed areas, data collected, and results of each surface surveyed area are presented in Sections 8.0, 9.0 and 10.0 of this report for the Empire, Balboa West, and Piña Ranges respectively.



**Figure 3-1 Burned Range Area**

### **3.2.2 SI Subsurface Survey**

Subsurface surveys entailed the use of anomaly locators and detectors throughout the sample area to record the number of targets. The target locations were then marked so a percentage of them could be interrogated. The percentage interrogated was a function of the area covered, sampling methodology used, and the total number of targets in that particular area. The types of detection technologies used for the subsurface surveys are covered in Section 4.0 of this report. The areas subsurface surveyed, data collected, and results of those surveys are presented in Sections 8.0, 9.0 and 10.0 of this report for the Empire, Balboa West, and Piña Ranges respectively. Figure 3-2 depicts one of the subsurface detectors being employed.

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Piña and Balboa West Ranges*

## **4.0 UXO DETECTION TECHNOLOGIES**

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This section covers the specific UXO detection technologies used during the SI effort. Background information, detection platform, and specific technology descriptions are presented in the sections below.

### **4.1 Background: Initial UXO Detection and Interrogation Technology Evaluation**

UXO Detection technologies for use in Panama were initially examined in the January 1997 report. UXO detection refers to locating and potentially identifying surface and subsurface anomalies. The preliminary evaluation report focused on the effectiveness and implementability of the technologies in the Panamanian environment. Five categories of UXO detection sensors were evaluated in that report: passive magnetometry, active electromagnetic (EM) induction, ground-penetrating radar (GPR), infrared (IR), and a multisensor approach (which is a combination of one or more of the other four sensor categories). UXO detection sensors were further evaluated according to the following operational platforms: airborne, vehicle-towed, and man-portable. Two basic criteria were used in the initial report, to evaluate UXO detection technologies (sensor) (1) effectiveness for the intended purpose and (2) implementability. These criteria are defined as follows:

- Effectiveness:** the ability of the technology to detect or interrogate UXO.

- Implementability:** the technical feasibility, i.e. the capability of the technology to perform at the site.

The results from that initial assessment are listed in Table 4-1. The majority of the technology performance information presented in that report was obtained from controlled site technology demonstrations conducted under the USAEC and NAVEODTECHDIV Advanced Technology Demonstration (ATD) Program. During Phase I of the ATD Program, 29 systems were demonstrated; during Phase II of the program, 20 systems were demonstrated. Phases I and II were both conducted at a controlled test site (with inert ordnance placed at known depths and locations) at Jefferson Proving Grounds (JPG) in Madison, Indiana. In addition systems that performed well during the Phase I controlled site demonstrations and new systems with high performance expectations were further tested at one or more sites that contained live ordnance.

Table 4-1 UXO Detection Technologies

Category	Technology	Capabilities and Limitations	Effectiveness	Potentially Applicable in Panama*
UXO Detection Sensors	Passive Magnetometry	<ul style="list-style-type: none"> <li>•Detects only ferromagnetic, iron-based metal objects</li> <li>•Sensor should be placed close to the soil surface to optimize performance</li> </ul>	High to Medium	Yes
	Active EM Induction	<ul style="list-style-type: none"> <li>•Detects all types of metals</li> <li>•Sensor should be placed close to the soil surface to optimize performance</li> <li>•Potentially unsafe if electronically fused ordnance is present</li> </ul>	Medium	Yes
	GPR	<ul style="list-style-type: none"> <li>•Detects metallic and nonmetallic objects</li> <li>•Severely limited by vegetation and wet soils</li> </ul>	Low to Not Effective	No
	IR	<ul style="list-style-type: none"> <li>•Detects only surface ordnance</li> <li>•Limited by vegetation</li> <li>•No field-proven systems available</li> </ul>	Low to Not Effective	No
	Multisensor	<ul style="list-style-type: none"> <li>•Collects and combines data from two or more sensors</li> <li>•Higher probability of detection and lower FAR than single-sensor systems</li> <li>•Systems may be more expensive and complex</li> </ul>	High to Medium	Yes

\* Potentially Applicable in Panama where the Site is Accessible

❖ bgs = Blow Ground Surface

❖ FAR= False Alarm Ratio

In addition to evaluating technology categories the report also evaluated detection platforms including airborne, vehicle-towed and man-portable. From the initial preliminary evaluation results, it was concluded that airborne detection platforms would not be effective in Panama due to foliage and past performance of airborne systems at the JPG. The preliminary report also concluded that vehicle-towed UXO detection systems would be effective and implementable in areas on the ranges that are currently accessible to vehicles, or that would be accessible with limited road construction (<5% of the area). The preliminary assessment concluded that man-portable UXO detection systems would be effective and implementable in many areas of the ranges in Panama, but not in steeply sloping or very densely vegetated areas, which would severely hinder the employment of any UXO detection technology.

## **4.2 Site Investigation Detection Technologies and Platforms Introduction**

The preliminary evaluation was used to select the specific detection technologies and methods of deploying these technologies for the SI effort. Two categories of technologies, GPRs, and IR were ruled out from the start. GPR was ruled out because of vegetation cover and terrain while IR was ruled out because of a lack of detection penetration depth (surface or near surface only). The three remaining categories that were promising included: passive magnetometry, active EM induction systems, and a multi-sensor approach. Two specific technologies from the first category, passive magnetometry, were selected for the SI: a cesium vapor magnetometer system using a Geometrics™ G858 magnetometer and the Schonstedt™ GA-52CV magnetic locator. One active EM system was used; the Geonics™ EM61 time domain metal detector. The third category, multi-sensor approach, was obtained by using technologies from the passive magnetometry and EM categories together. There is a distinct difference between a passive sensor and an active sensor. Passive sensors detect signals but do not generate any signals themselves, while active sensors generate signals and measure the associated responses. This distinction is important because in rare cases certain UXO items may be susceptible to the signals produced by an active sensor, thus causing it to detonate.

From the results of the initial preliminary evaluation, airborne detection platforms were ruled out for the SI effort. Although applicable in limited areas a vehicle system was not utilized in the SI effort due to the environmental characteristics of the specific areas targeted for investigation. Most areas were located in areas of steep jungle terrain and contained overgrowth, which made it unfeasible for a vehicle-towed system. Only man-portable configurations of the UXO detection technologies were used during the SI effort. Specific performance and implementability issues associated with the detectors and platforms used, will be covered in detail in a second report entitled "Engineering Evaluation of UXO Detection and Interrogation Technologies in Panama: Empire, Balboa West and Piña Ranges".

A description of each technology category along with the specific sensors selected from each category and method of employment is provided below.

## **4.3 Passive Magnetometry - Background - Magnetism**

The earth has a natural magnetic field that resembles a large bar magnet near its center. The intensity of the field, a function of the density of the "flux lines", is approximately twice as intense in the polar region as in the equatorial region, or approximately 60,000 and 30,000 gammas respectively.

Ferrous materials also have a magnetic field associated with them. The measured intensity of the field is dependent upon many factors including the size, shape, and type of material. Sensors used to measure the intensity of magnetic fields are called magnetometers.

#### **4.3.1 Passive Magnetometry for Ordnance Detection**

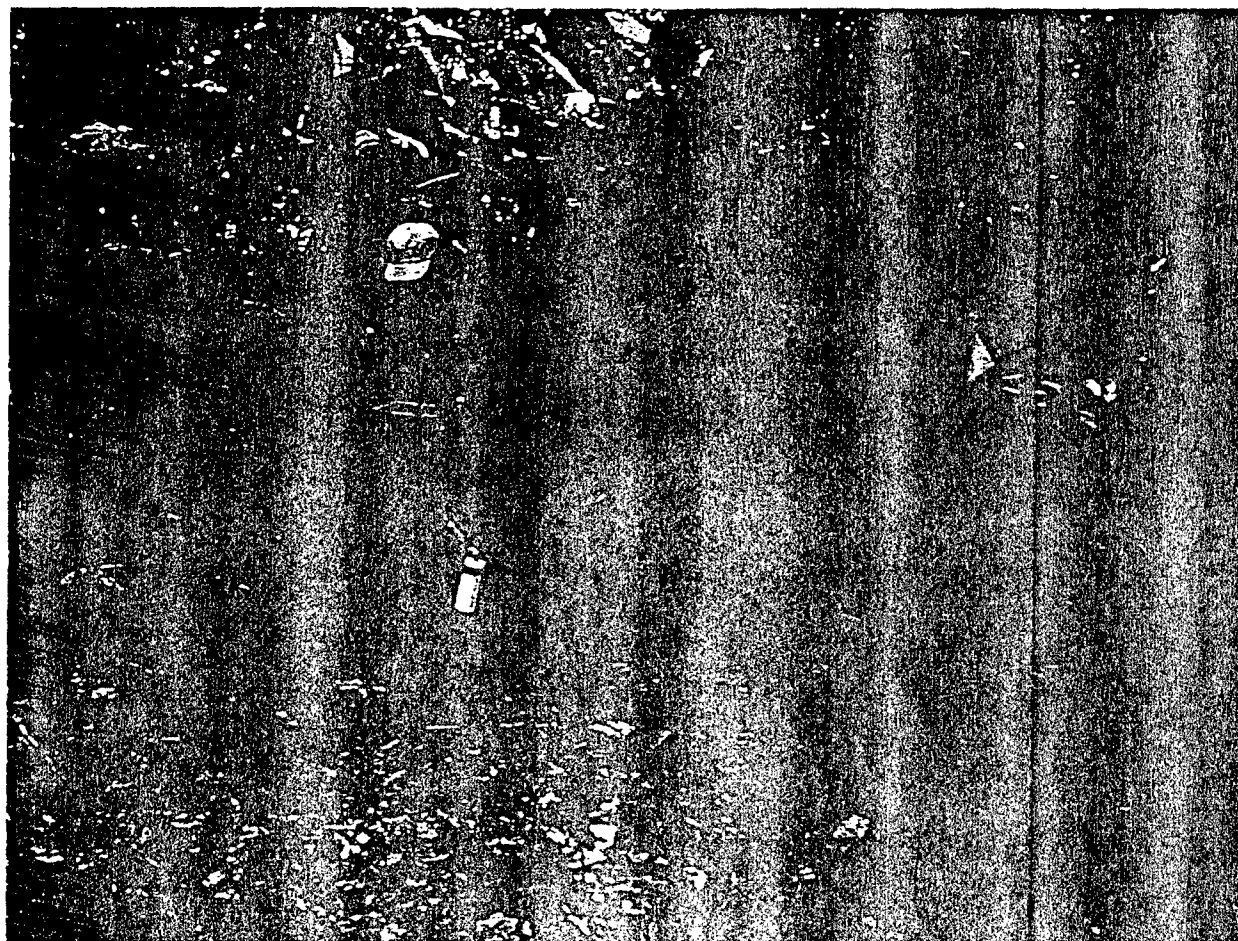
Passive magnetic sensors locate buried ferromagnetic anomalies by detecting irregularities in the earth's magnetic field caused by ferrous materials. Since most ordnance items contain some ferromagnetic material the sensor technology principles are valid for locating buried UXO. The exact amount and type of ferromagnetic material in each ordnance type depends upon the particular design of the item. Magnetic responses from buried ordnance items tend to have magnetic intensity values that range down in the 1's to 100's of nanoTesla, or gamma range, depending upon its orientation relative to the earth's magnetic field and distance from the sensor. The peaks and spread of the readings are used for discriminating target types, depths and orientations.

Each specific passive magnetic sensor type is different, however most detectors have the following components: sensor(s) power supply, electronics package, and annunciator or visual display. Some systems include a computer data system and a means to record locations of detected anomalies. Two specific magnetic sensors selected from this category include a cesium vapor magnetometer system using a Geometrics™ G858 magnetometer and a Schonstedt™ GA-52 CV magnetic locator. A description and method of employment of each system is provided below.

##### **4.3.1.1 Geometrics™ G858 Magnetometer**

The Geometrics G858 is a cesium vapor magnetometer that measures the total magnetic field intensity at the sensor's location. Detection of ferrous anomalies is accomplished by observing rapid spatial changes of the earth's ambient magnetic field. The earth's natural magnetic field, which varies from 30,000 nanoTesla (nT) around the equator to 60,000 nT around the poles, is disturbed by local sources of magnetic fields such as those given off by buried UXO that have ferrous content. These abrupt changes are detected in the G858 and presented to the operator by either an increase or decrease in the nanoTesla readings on a digital display. An audio indicator also alerts the operator to any changes in the earth's magnetic field. When feasible, systematic sampling or surveying using defined grids and use of a reference base station, increase the detection range and sensitivity of the magnetometer. The exact number of readings taken for a particular survey is dependent upon the sampling frequency and speed the

sensor is moving across the area. A typical survey of a 10 by 10-meter area would involve 1,000 – 5,000 readings depending upon the sample separation. Survey or grid readings are evaluated with respect to each other using software algorithms and other data processing techniques.



**Figure 4-1 G858 Instrument**

#### ***4.3.1.1.1 Method of Employment***

The G858 can be employed as a hand held (HH) unit that the operator carries steady while walking forward at a constant speed (used in the survey mode), or employed in a sweeping motion over the suspect area in the “mag and flag” mode where targets are marked as soon as they are found. The height of the sensor off the ground is 6 to 12 inches depending upon the background noise and environmental conditions at the survey site. When the locator comes within range of a ferrous object, a higher frequency is emitted from the speaker and the corresponding local magnetic field intensity is displayed and recorded. After a target is detected the operator moves the locator back and forth in an “X” pattern to find the area

affecting the signal including the signal peaks. The signal behavior can be used to estimate the size and depth of the particular anomaly.

#### ***4.3.1.2 Schonstedt™ GA-52CV Magnetic Locator***

The Schonstedt detects the local magnetic field using two individual sensors oriented one on top of the other 20 inches apart. The configuration is commonly referred to as a gradiometer because the detector locates anomalies by the magnitude of the difference in the responses of each sensor. The output of the Schonstedt is an audio response through a built-in loudspeaker. When the first sensor's readings match that of the second sensor the audio output emits an idling response. As the detector is positioned over a ferromagnetic anomaly the reading from the lower sensor will be different from the reading in the upper sensor. As a result of the difference in readings, the pitch of the audio output increases, i.e., the greater the difference, the higher the pitch. The unit has a sensitivity adjustment feature which allows the operator to adjust the idle and output response range of the system. The detector is a HH unit weighing approximately 1.36 kg. with a length of about 110 cm. Standard "C" size batteries power the unit.

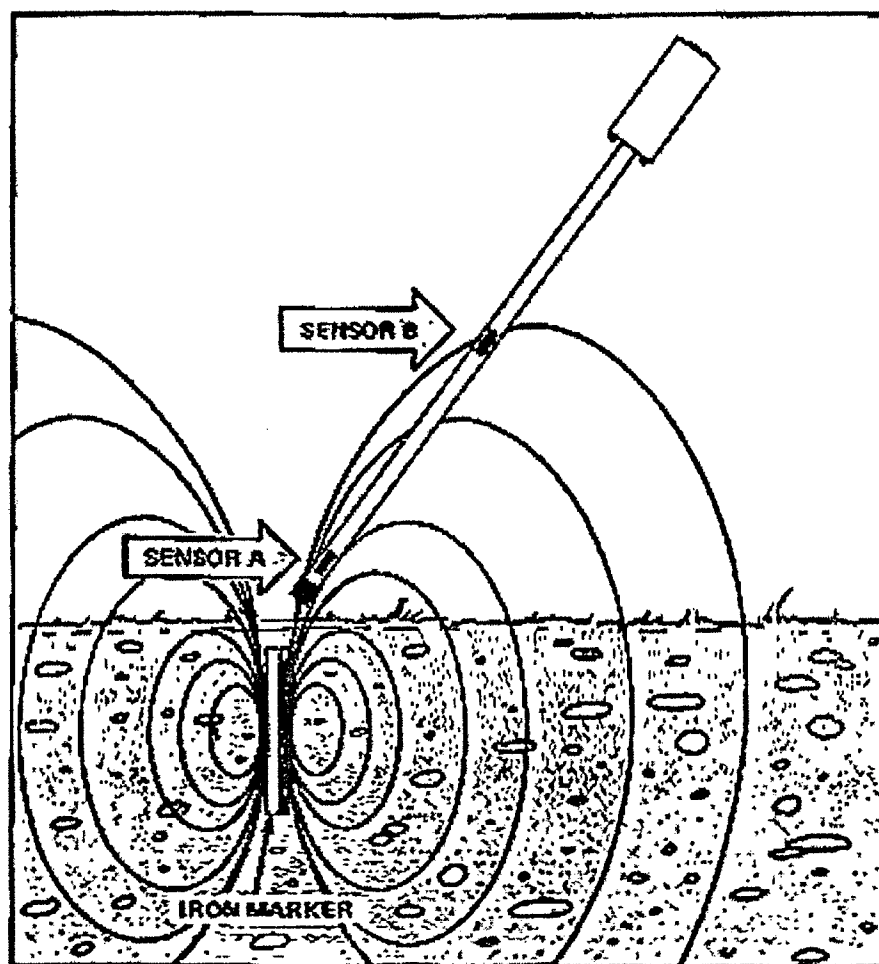


Figure 4-2 Schonstedt Ferrous Locator – Gradiometer Configuration

#### 4.3.1.2.1 Method of Employment

The detector is a HH unit, which the operator waves in a sweeping motion over the suspect area. The sensor is held at a height of 6-12 inches from the ground, depending upon the background noise and environmental conditions at the survey site. When the locator comes within range of a ferrous object, a higher frequency is emitted from the speaker. After a target is detected the locator should be held vertically and moved back and forth in an "X" pattern to find the area affecting the signal including the signal peaks. The signal behavior can be used to estimate the size and depth of the particular anomaly. For example, Figure 4-4 shows basic signal patterns for the Schonstedt buried in two different configurations.

### Basic Signal Patterns

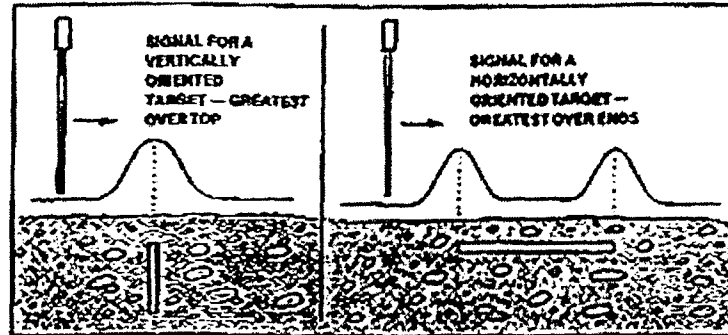


Figure 4-3 Basic Signal Pattern For The Schonstedt Ferrous Locator

The height and sensitivity setting of the instrument can also be adjusted to estimate the target size and depth. For example, signals that drop sharply off when the instrument is raised a couple of inches off the ground or when the sensitivity is slightly adjusted, are probably the result of a very small target close to the surface such as a bolt or other small ferrous object. Once the target has been estimated, its location is marked and surveyed in for later interrogation.

#### 4.3.2 Electromagnetic Induction for Ordnance Location

EM induction systems are active sensors, which transmit electronic current or signals into the ground. When the signal contacts a metallic item it induces eddy currents into that item. The eddy currents cause a time-varying secondary EM field. The locator then either measures components of the secondary induced EM field or the difference between the electrical conductivity of the soil and the buried object.

##### 4.3.2.1 Geonics™ Electromagnetic (EM) 61 Time Domain Metal Detector

There are two configurations of the Geonics EM61 that were used in Panama for the SI effort; the EM61 cart configuration and the EM61 HH configuration. The cart configuration has one transmit coil and one receive coil, each measuring 1 meter squared. The coils are mounted in a boxlike configuration 40 cm apart. The transmit coil sends a pulsed primary magnetic field into the earth which causes eddy currents in nearby metallic objects. The eddy current decay produces a secondary magnetic field that is measured by the receiver coil. The EM61 HH configuration is a scaled down version of the EM61 cart mode but the coils are positioned on a hand held wand. The system uses the same electronics backpack and data logger as the EM61 cart mode. Information is collected twice at different times, an early response at 1 time gate and a second response at 2 time gates. Collecting data from 2 gates, early and late, provides the

user with better discrimination capabilities. Figure 4-5 shows the EM61 cart mode, while Figure 4-6 shows the EM61 HH.



Figure 4-4 EM61 Cart



**Figure 4-5 EM61 Hand Held Mode**

#### ***4.3.2.1.1 Method of Employment***

Again, only man-portable configurations were considered for the SI effort. The man-portable EM61 detector basically is available in two configurations, the wheeled cart mode and the smaller HH mode. The cart was designed to survey areas of flat terrain and low ground cover. The wheeled cart configuration requires the user to pull a cart behind him over the survey area. As the cart is pulled over the area at a slow even rate, data is captured in the data logger backpack electronically. The smaller EM61 HH unit is hand held in front of the surveyor as the area is traversed. The detector head is held parallel to the ground at a distance of 6-12 inches depending upon the level of background noise. As the area is surveyed the data logger collects sensor data for post processing. In Panama, the EM61 HH was also used in a “treasure hunt” or “mag and flag” mode. This mode involves placing flags or markers at every suspect UXO spot as the operator progresses along a line.

## **5.0 SITE INVESTIGATION APPROACH**

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To meet the objectives of the SI for the ranges in Panama a couple of sampling techniques, methodologies, and statistical tools were used including transect sampling, and random grid sampling. Transect sampling involves sampling a random slice of an area where density values are expected to change during the progression of the transect. Random grid sampling involves marking discrete grids of random size and placement throughout an area of concern and sampling those grided areas for UXO concentrations.

The information gained from each SI activity and sampling methodology is combined in this report to provide an overview of the potential UXO concentrations to date on the Empire, Balboa West, and Piña Ranges in Panama. Additional information on each of the methodologies, sampling, and clearance efforts can be obtained through the appropriate agency responsible for that particular portion of the SI. Appendix A lists the point of contact for each agency or organization. In addition to the UXO clearance, sampling, and characterization efforts, USARSO conducted a large scale Range Policing effort. The Range Policing effort included surface sweeping of maneuver and training areas for various range related items including UXO. A description of each technique and methodology is provided below along with the range areas and where they were employed.

### **5.1 Transect Methodology**

USAEC working with NAVEODTECHDIV were responsible for conducting a sampling effort to gather field data on very-low and suspect or unknown UXO concentration areas, as defined in the UXO Assessment report. Areas classified as having very-low UXO density levels were limited to the range firing fan areas. The firing fans areas were classified as very-low UXO concentration areas because of the possibility of short-fired, skipped, or rounds that have ricocheted. Firing fan dimensions used in the UXO assessment report were based on the particular characteristics of the weapon type being utilized and the target locations on the ranges in Panama. Suspect or unknown areas are defined as areas that were not directly identified to contain UXO but anecdotal information existed which suggested that UXO might be present.

It was decided to use a transect method of sampling to meet the objective of validating information presented in the UXO Assessment Report, confirming and redefining UXO density boundaries, and gathering field data on the very-low, and suspect or unknown areas. The use of transects to identify areas exhibiting specific characteristics involves surveying a straight path which slices through the area of

concern. The initial UXO assessment report characterized the entire range fan areas as very-low. However, in the extreme rare case that a dud occurred within the immediate vicinity of the FP, that item would normally be attended to by EOD immediately because of the potential danger to the troops and equipment occupying that firing point area. As one traverses down range toward the impact area, theoretically the probability of encountering UXO due to short-fired rounds increases. The locations of the transects were driven by accessibility and environmental conditions of the areas. Areas of steep terrain, very dense vegetation, or environmentally sensitive areas were avoided. The transect sampling paths were set up from the firing points working towards the impact area.

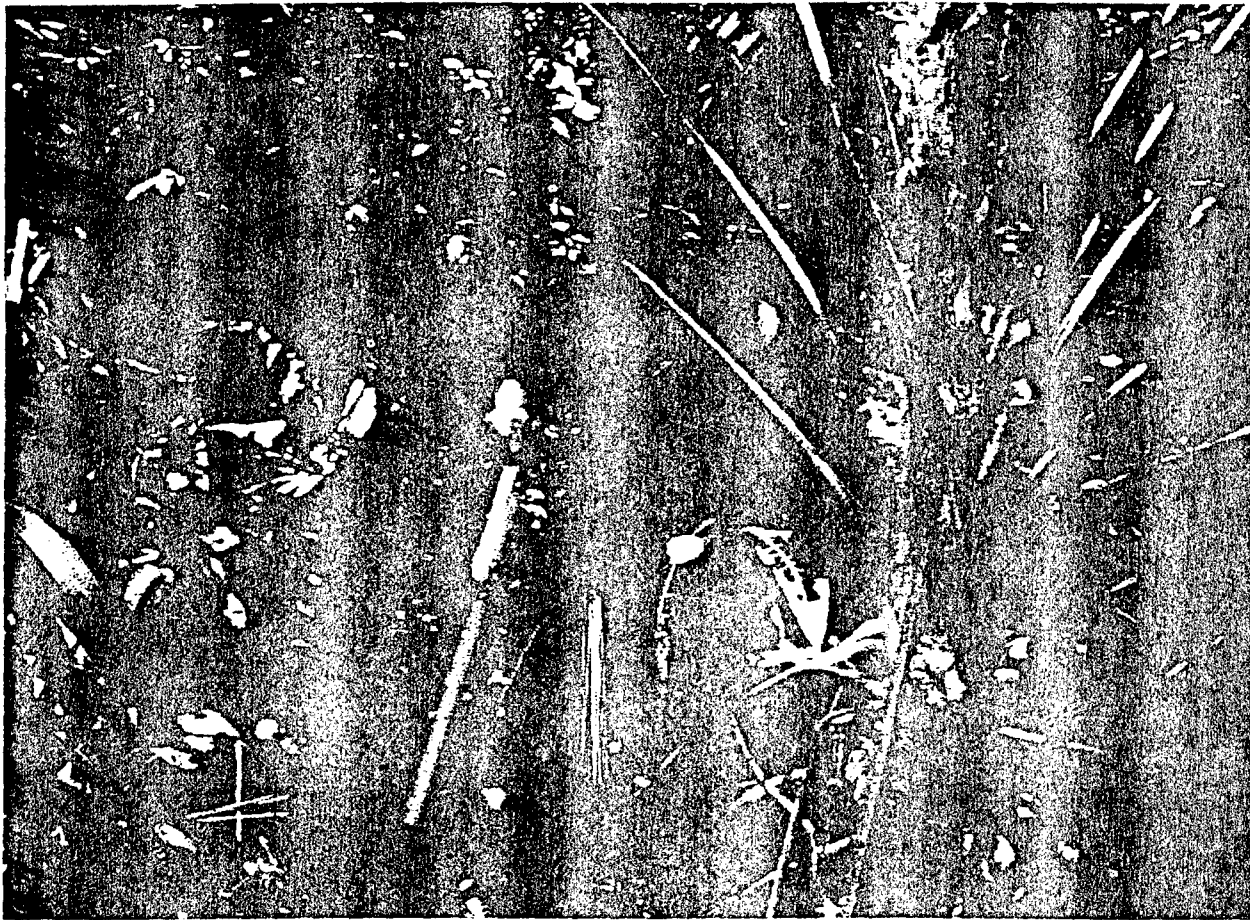
Suspect areas are defined as areas that were not directly identified to contain UXO but anecdotal information existed which suggested that UXO might be present. Suspect areas have an extreme amount of uncertainty associated with them, therefore there was no methodology for selecting the bearing or placement of transects within these areas. The decision for transect placement was based on site accessibility and location with respect to a road.

Individual transects consisted of a series of individual straight-line segments. The number of segments varied from 2 to 21 and lengths from 12.9 meters to 138.6 meters depending upon the environmental characteristics of the transect path. A change in bearing or other transect characteristic marked the start of a new transect segment. Areas of very steep terrain, very dense vegetation, or environmentally sensitive areas were avoided. In every case transects were positioned in such a way as to provide the maximum in area coverage and quality of data collected.

Transect surveys were conducted using both surface and subsurface detection technology sweeps along transect lanes that cut through areas outside known impact areas. The surface surveys included visual surveys aided by a Schonstedt GA-52CV while the subsurface surveys were conducted with the EM61. The Schonstedt provided a quick response to any ferrous items located on or close to the surface. It was also easy to carry and to operate. The EM61 was selected because of its ability to detect both ferrous and non-ferrous conductive items as well as its performance on the controlled calibration reference area, which is presented in Section 6 of this report. The process involved in the transect surveys is presented in the next section.

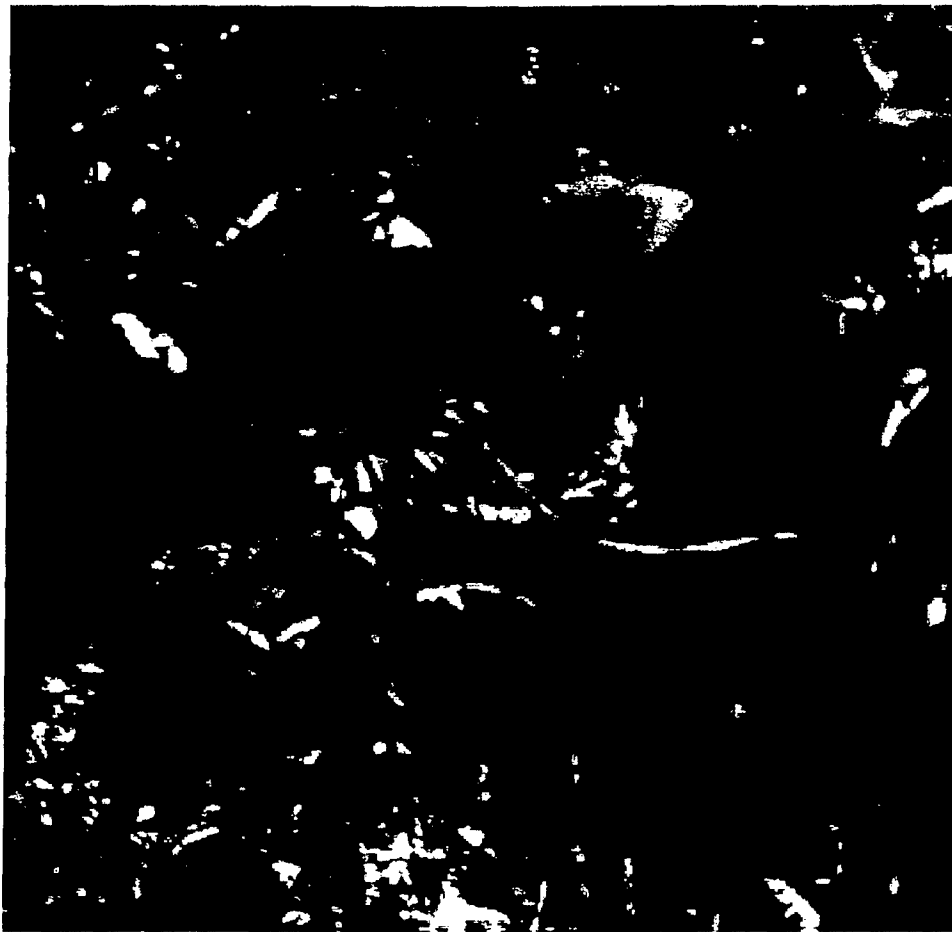
## **5.2 Transect Process**

The transect SI team consisted of two UXO specialist escort personnel, four surveyor/surface clearing personnel, two geophysical scientists and four UXO excavation personnel. The EOD escort personnel led the team into the jungle sweeping the surface for UXO or ordnance related items and flagged the items using nonmetallic pin flags (Figure 5-1). A Schonstedt GA-52CV ferrous metals locator was used to aid the escort personnel in the visual surface sweep.



**Figure 5-1 EOD Escort with Schonstedt**

The escort team was followed by the four survey/transect clearing personnel (Figure 5-2). They cleared the vegetation and overgrowth allowing for a 2-3 meter-wide trail to be cut through the jungle. The survey/transect clearing crew had a transit (survey equipment) to measure the distance and bearing of each segment of the transect with an accuracy of a tenth of a meter or degree respectively. Stakes were placed by the surveyor team to demarcate the start and end points of each transect segment along the entire length of the transect.



**Figure 5-2 Clearing Crew with Hand Held Tools**

After escort personnel and the survey/transect clearing personnel established the transect and flagged all of the surface ordnance and nonordnance anomalies, the geophysical team (Figure 5-3) traversed the area with the subsurface detection equipment. The geophysical team surveyed the entire width of the transect and marked and measured anomalies as they progressed "mag and flag" through the transect. The sensor readings for each anomaly were recorded along with their position relative to the start of the transect segment.



**Figure 5-3 Geophysical Crew**

After the anomalies were surveyed and marked, the UXO excavation team interrogated the marked targets. The interrogation team used various hand tools, including picks and shovels, to excavate the targets slowly and carefully in order to minimize the forces exerted on the target.

### **5.3 Transect Sampling Data Collection**

The following paragraphs discuss the data collected during the surface and subsurface investigations performed during the transect survey.

### **5.3.1 Surface Investigation**

UXO specialist personnel who escorted the survey team through the transects recorded information on type, size, and condition, of any UXO or ordnance related item encountered on or near the surface. Pin flags were used to mark the surface or near-surface anomalies identified by the escort team, and their relative locations within the respected transect segment were measured and recorded.

### **5.3.2 Subsurface Investigation**

A professional subsurface survey team collected subsurface data using an all metals EM61 sensor. The collected sensor data was interrogated in real time by the survey team and anomalies were identified by location relative to the transect section. Anomalies were marked with pin flags and spray paint, the locations and maximum sensor readings were measured and recorded for validation.

### **5.3.3 Anomaly Interrogation**

The UXO excavation team recorded the type, size and depth of each target. The excavation area was rechecked with a subsurface locator, and excavation continued if the sensor indicated the presence of further target material. Excavation continued until all target material was removed and the sensor no longer indicated the presence of an anomaly, ensuring that 100% of the detected target material was interrogated.

## **5.4 Areas Surveyed Using Transect Methodology**

A total of 16 transects were surveyed on the three ranges in Panama: seven transects on Empire, 4 on Balboa West and 5 on Piña. The transect locations were selected by a prioritized ranking based on three factors: the type of ordnance used at that location, activities of the other UXO sampling teams (USACE and TF111 EOD), and accessibility of the site. Principally, transects were selected based on accessibility from a road and had to be traversability by an emergency crew in the event of an accident. The survey team began by staking the starting point of each transect which was always located off an established road. The road stakes were surveyed in with a hand held Global Positioning System (GPS) unit. Transect segments and anomaly locations beyond the established road stake were then referenced back to that location for each transect. The jungle overgrowth and terrain made it impossible to use GPS for surveying in the absolute positions of the anomalies. Additional data on navigation systems for UXO

detection technologies is covered in the EE report. The following sections cover the transects surveyed at each of the ranges in Panama.

#### 5.4.1 Transects Surveyed On The Empire Range

A total of 7 transects were surveyed on the Empire Range including the areas defined in the UXO Assessment Report as: the EOD range kickout area; the firing fan associated with range 19; Camp Bayonet; the western portion of suspect impact area of range 6; the firing fan associated with FP-11; the firing fan associated with FP-15, and; the Tire House Complex. Table 5-1 lists the starting point (northing and easting), and total length of each of the 7 transects surveyed on the Empire Range.

**Table 5-1 Transects Surveyed On The Empire Range**

<b>Transect</b>	<b>Location</b>	<b>Northing</b>	<b>Easting</b>	<b>Length (m)</b>
A	EOD Kickout Area	09 95 639	17 649 712	351.2
B	Range 19 Firing Fan	09 94 333	17 653 060	742.7
C1	Camp Bayonet	09 97	17 64	200.0
C2	Suspect impact area of Range 6	09 97 482	17 645 592	929.9
D	FP-11 Firing Fan	09 95 639	17 648 673	369.0
E	FP-15 Firing Fan	09 97 194	17 645 735	326.5
K	Tire House Complex	09 97 786	17 643 721	326.7

- ❖ Northings and Eastings in WGS84 datum.
- ❖ GPS error of +/- 100 meters.

Table 5-1 illustrates the transects covered on the Empire Range. The distance and bearings of each individual segment for each transect can be found in Appendix D. In addition to the 7 (surface and subsurface surveyed) transects, the Rio Fuentes drainage area near the southwest corner of the Main Impact Area, were surface swept for UXO and ordnance related material.

#### 5.4.2 Transects Surveyed On The Balboa West Range

A total of 4 transects were surveyed on the Balboa West Range in the area south of the Tactical Targets, as defined in the UXO Assessment Report as: the suspected former Army-Navy series bombing area; the area suspected of being an UXO concentration area associated with Army ground ordnance testing; the area just outside the hourglass shaped bombing pattern of Tactical Target 8 (TT-8); and the area just outside the hourglass-shaped bombing pattern of Live Ordnance Area-A (LO-A). Table 5-2 lists the

starting point (northing and easting), and total length of each of the 4 transects surveyed on the Balboa West Range. Transects were not conducted in the areas north of the Tactical Targets because of site inaccessibility.

**Table 5-2 Transects Surveyed On The Balboa West Range**

<b>Transect</b>	<b>Location</b>	<b>Northing</b>	<b>Easting</b>	<b>Length (m)</b>
F	Army-Navy series bomb area	09 98 528	17 640 568	1004.9
G	Army ground ordnance test area	90 99 800	17 640 056	520.4
H	Outside TT-8 bombing pattern	09 100 259	17 64 0 362	515.7
J	Outside LO-A bombing pattern	09 100 0326	17 640 371	563.6

- ❖ Northings and Eastings in WGS84 datum.
- ❖ GPS error of +/- 100 meters.

Table 5-2 illustrates the transects covered on the Balboa West Range. The distance and bearings of each individual segment for each transect can be found in Appendix D.

#### **5.4.3 Transects Surveyed On The Piña Range**

A total of 5 transects were surveyed on the Piña Range including the areas defined in the UXO Assessment Report as: the area northeast of the main impact (two transects); the area 500 meters north of firing fan associated with FP-4; the area just below the Rio Providencia washout area; and the boundary between training areas P-4 and P-5. Table 5-3 lists the starting point (northing and easting), and total length of each of the 5 transects surveyed on the Piña Range.

**Table 5-3 Transects Surveyed On The Piña Range**

<b>Transect</b>	<b>Location</b>	<b>Northing</b>	<b>Easting</b>	<b>Length (m)</b>
L	Northeastern Area	10 214 90	61 5033	578
M	Northeastern Area	-	-	275
N	North of FP-4 Firing Fan	10 187 35	61 4687	712
P	Below Rio Providencia Wash-out Area	10 183 05	61 0310	946
Q	Boundary between TAs P-4 & P-5	10 172 76	61 1978	308

- ❖ Transect M has no starting point because it bi-sectioned transect L
- ❖ Northings and Eastings in WGS84 datum.
- ❖ GPS error of +/- 100 meters.

Table 5-3 illustrates the transects covered on the Piña Range. The distance and bearings of each individual segment for each transect can be found in Appendix D.

## **5.5 Random Grid Sampling**

USACE and TF 111 EOD utilized random grid sampling methodologies to collect UXO characterization data for the SI effort. Section 5.5.1 covers the USACE sampling methodology, process and areas covered. Section 5.5.2 covers the TF 111 EOD sampling methodology, process and areas covered.

### **5.5.1 USACE Random Grid Sampling Methodology**

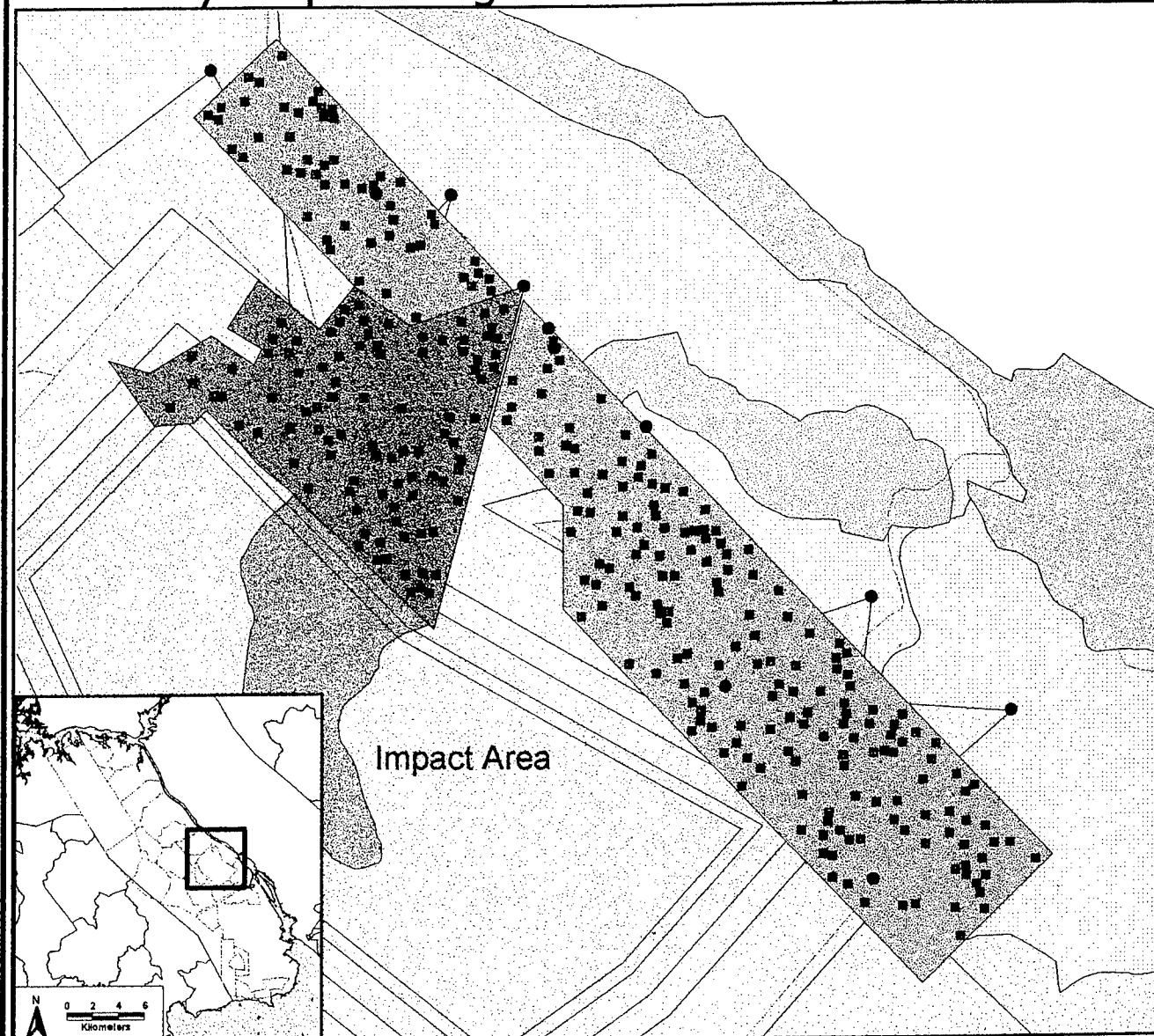
USACE, working from a tasking from the PCC, was responsible for site characterizing areas of the Empire Range that may be affected by the canal widening and third lock projects. USACE utilized a random grid sampling system that has been used at several FUDS in the United States. A two level sampling methodology was used. The first level involves dividing the site into areas of similar homogenous features. These areas are known as sectors. The second level of the sampling methodology involves placing random grids throughout each sector to be surveyed. Once the grids are surveyed, a percentage of the anomalies detected are then interrogated. To provide guidance in the sampling process a statistical based software program known as Site Stats and Grid Stats was used. The Site Stats and Grid Stats sampling process is defined in Sections 5.5.1.1 and 5.5.2.1 and the sampling grids are shown in Map 5-1.

#### **5.5.1.1 USACE Random Grid Sampling Process**

Site Stats indicated that the area could be divided into three sectors, each containing similar terrain and environmental characteristics. Next, Grid Stats developed a sampling plan that determined the size and placement of the survey grids. A total of 313 randomly selected grids were surveyed in the three sectors.

Once the grids were marked and cleared of vegetation, the survey team conducted a surface sweep for UXO within the grid. The team then proceeded to subsurface survey each grid area with the Schonstedt ferrous metals locator. Only a percentage of the anomalies detected were interrogated. The results of the random grid USACE sampling effort are combined in Section 8 of this report, SI Empire Range.

# Army Corps of Engineers UXO Sampling Grids

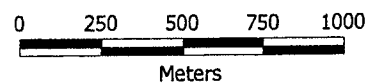
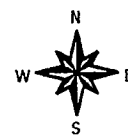


## Legend

- Firing Points
- Army Corps of Engineers Sampling Grids
- Sector 1
- Sector 2
- Sector 3
- Initial UXO Concentrations
- Very High UXO Concentration
- High UXO Concentration
- Medium UXO Concentration
- Low UXO Concentration
- Very Low UXO Concentration
- Suspected UXO Concentration
- No Known UXO Concentration

Map Not To Scale

## Empire



Map 5-1 Army Corps Of Engineers UXO Sampling Grids

#### **5.5.1.2 Areas Surveyed by USACE using the Random Grid Sampling Methodology**

313, 30 meter x 30-meter grids were statistically identified for sampling within 3 separate sectors. Sector 1, at 44.9 hectares, contained 52 grids; sector 2, at 82.4 hectares, contained 93 and sector 3, at 153.5 hectares, contained 173 grids. The 3 sectors were located in the Main Impact Area on Empire and overlapped with parts of the firing fans associated with Ranges 7, 8 and 10. The three sectors were statistically positioned to collect data for the canal widening effort and the canal lock construction area.

#### **5.5.2 TF 111 EOD Random Grid Sampling Methodology**

TF 111 EOD working under tasking from USARSO conducted UXO characterization surveys at various locations on the Empire Range using random grids. The TF 111 EOD used 50 feet x 50 feet grids that were placed randomly in accessible areas of the particular area of concern. A statistical sampling program such as Site Stats and Grid Stats was not utilized because the sizes of the areas of concern were relatively small instead the grids were randomly placed in accessible areas of the range.

##### **5.5.2.1 TF 111 EOD Random Grid Sampling Process**

The grids were marked in the field and the EOD survey team conducted a surface sweep for UXO and range debris, and then proceeded to subsurface survey the grided areas with various detection technologies including the MK 26. The original plan called for investigation of anomalies to 24 inches (2 feet); however, soil conditions and compacted dry-season clay made digging to that depth very difficult in all areas. As a result, TF 111 EOD personnel dug anomalies to various depths, not exceeding 2 feet. The results of their characterization efforts are combined in Section 8 of this report, SI Empire Range.

##### **5.5.2.2 Areas Surveyed by TF 111 EOD using the Random Grid Sampling Methodology**

TF 111 EOD was tasked with performing UXO site characterizations at 5- non impact areas within the Empire Range complex including the old ASP in Training Area 42 (TA-42), Camp Bayonet, Observation Point 4 (OP-4) in TA 49, Tire House complex and Range 1/1A.

#### **5.6 Surface Clearance**

The USAF and TF 111 EOD assets were tasked with surface clearing UXO and Range debris from various locations throughout Empire, Balboa West and Piña. Areas were selected based upon range usage, previous range sweep activities, and information presented in the initial UXO Assessment report.

### **5.6.1 Surface Clearance Methodology**

The methodology used in the surface clearance activities was to clear the accessible portions of each area visited of surface UXO and range debris including ordnance and explosive (OE) scrap and non OE scrap.

#### **5.6.1.1 Surface Clearance Process**

EOD teams of various sizes conducted surface clearance activities at locations in the Empire, Balboa West and Piña Ranges. The results of the surface clearance activities are covered in Sections 8, 9 and 10 for Empire, Balboa West and Piña ranges respectively.

#### **5.6.1.2 Areas Surface Cleared for the SI**

Areas surface cleared on Empire by TF 111 EOD assets included Range 7, Range/Firing Point (FP) 7A, Range 8, Range 10, EOD Range, Portions of the Main Impact Area and portions of roads K10, K19, K15 and K6.

Areas surface cleared on Balboa West by USAF EOD assets included TT 1,2,3,4,5,6,7 and 8 (TT's 1-8) and LO-B.

Areas surface cleared on Piña by TF 111 EOD assets included the Live Fire Village, the Multi-Purpose Range and the Demolition Range.

### **5.7 USARSO's Range Policing**

Range policing activities were coordinated and conducted by USARSO assets. Range policing activities involved personnel surveying accessible areas of the maneuver and training areas to collect and remove range debris including trash, old targets, UXO and ordnance related materials. These maneuver and training areas were not located on known impact areas and no evidence of ordnance usage was reported there, however, these areas were visually swept for re-assurance that no UXO existed in these areas and that all trash and military related debris and materials were removed from the areas. The data collected from these activities are included in this report because it provides information on the conditions of the maneuver and training areas.

### **5.7.1 Range Policing Methodology**

The methodology used was to visually surface sweep various accessible maneuver and training areas on the Empire and Piña Ranges and to remove any trash, old target materials, UXO and ordnance related or hazardous items.

### **5.7.2 Range Areas Policed**

Areas policed on the Empire Range included accessible sections of training areas: 30, 44, 48, 49, 50 (except Cerro Gordo), 53 and 54 (west of the pipeline). Other areas included parts of Camp Bayonet, FP 16, FP-20, Range 18, Range 19, Range 2, and Range 5. A total area of over 2,820 hectares (43% of the Empire Range Area) and approximately 25 miles of roads were policed. Areas policed on the Piña Range included training areas P-5 and P-6.

### **5.7.3 Range Policing Findings**

No UXO or hazardous materials were found during the police calls, however, truck loads of scrap and non-hazardous debris were removed from the ranges. Examples of specific items removed included empty 55-gallon drums, car bodies, pipes and other metal objects. These policing activities covered a substantial portion of the ranges and provide valuable information about the conditions of the maneuver areas in general.

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
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## **6.0 DETECTOR REFERENCE AREA**

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A reference area is an area designated for evaluating ordnance detectors in a controlled condition in an environment similar to where the detectors are to be utilized. An area of the range that has not been used in the past for ordnance testing and does not contain UXO or ordnance related debris was selected and known targets, similar to the ones expected to be found on the actual survey areas, were buried at depths that the equipment would be expected to detect. Various sensors were then used to survey the area to determine if the controlled targets could be found.

### **6.1 Purpose**

The purpose of a reference area is to assess the subsurface detectors operating performance on a known area, prior to implementing the technology in the field. This assures that the technologies do indeed work in the intended environment and provides a gauge for the capabilities and limitations of the detectors in the target environment. Many environmental factors affect the performance of the sensor including background noise associated with the local environment. Some instruments offer sensor settings that can be used to compensate for background noise levels. The reference area, therefore, serves as an area where subsurface detection equipment can be fine-tuned to local environmental conditions. The reference area allows the instruments to be tuned to a setting optimal for that local environment.

Using targets similar to the ones expected on the areas to be surveyed allows a direct comparison of the reference area data, to data captured during the actual field survey. Each target emplaced at the reference site is an additional control point for field data comparison. The response of a detector is a function of the parameters of the target itself, including type, size, mass, depth, orientation and altitude of the target in a given environment. Therefore, the more targets or control points there are in the reference area the more accurate the comparison data.

### **6.2 Area Layout**

The reference area was constructed on the Empire Range, behind the Hand Grenade Range 4, near Firing Point 16, coordinates 1001650 northing and 645950 easting. The reference area was well beyond the fragmentation range of the hand grenade range, and is located on an area, which has never been known to be used as an area for ordnance testing or training. The site reference area was rectangular in shape and

covered a surface area of 6,552 square feet. A total of 33 inert ordnance items were emplaced at the site reference area.

The targets included:

- one 250-pound (lbs.) bomb
- one 100-lbs bomb
- one Mark 19 practice bomb
- one BDU 33
- Three 155-millimeter (mm) projectiles
- five 82-mm mortars
- three 81-mm mortars
- eight 60-mm mortars
- ten 40-mm grenades

Prior to target emplacement the reference area was surface cleared of metallic debris and subsurface cleared with a Mark 26 ferrous ordnance locator. Several shallow surface items were removed, including wire, clothes hangers, piping, scrap metal, and concrete reinforcement bar that would have affected the sensor (see Figure 6-1). The purpose of pre-sweeping the reference area was to remove surface or near surface targets only, and not to eliminate all sources of noise including geologic noise.



**Figure 6-1 Scrap Removed From Reference Area**

All targets were emplaced at a depth no greater than 2 meters and were oriented in a north-south direction. That orientation provided the maximum sensor reading amplitude due to the relationship of the target, at that depth, with the earth's magnetic field. At several locations within the reference area, holes were excavated to depths ranging from 0.5 to 2 meters and backfilled without emplacing any ordnance item. This ensured that the surveyor was not reporting targets based on ground disturbance patterns. In addition all excavations were allowed to settle for about 1 week before the area was graded to the original surface elevation.

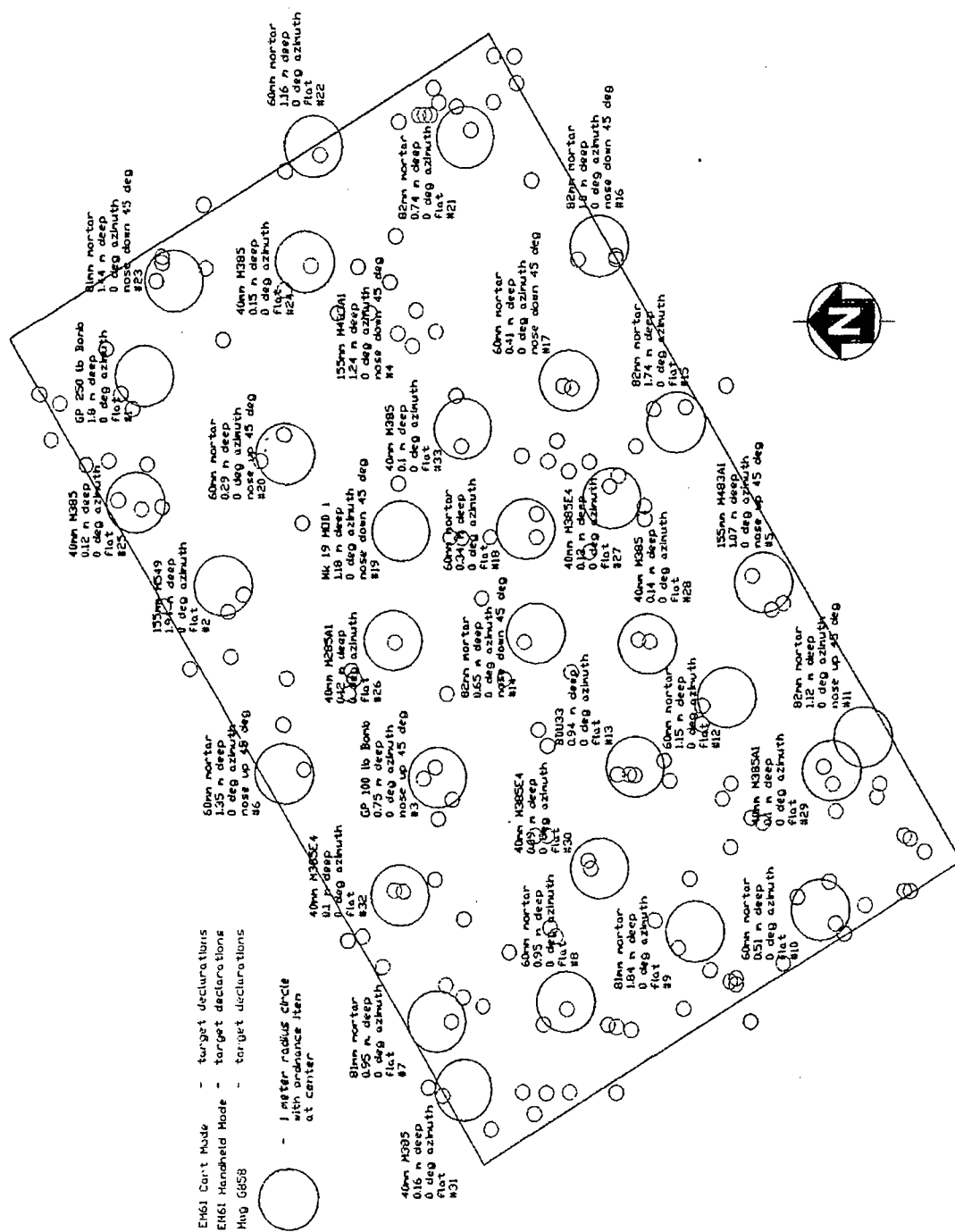
All target emplacement locations were surveyed in, and the target type, depth, orientation, and declination were recorded. An ordnance emplacement summary is presented in Table 6-1.

Table 6-1 Ordnance Emplacement Summary

Target No.	Key No.	Description	Depth (meters)	Declination (°)	Weight (kgs.)
1	B-1	GP 250-lb bomb	1.8	Flat	51.76
2	B-2	155-mm projectile	2.0	Flat	43.58
3	B-3	GP 100-lb bomb	0.8	Nose Down 45°	18.95
4	B-4	155-mm projectile	1.2	Nose Up 45°	23.84
5	B-5	155-mm projectile	1.5	Nose Down 45°	24.74
6	B-6	60-mm mortar	1.5	Nose Down 45°	1.73
7	B-7	81-mm mortar	1.0	Flat	4.65
8	B-8	60-mm mortar	1.0	Flat	1.73
9	B-9	81-mm mortar	2.0	Flat	4.77
10	B-10	60-mm mortar	0.5	Flat	1.73
11	B-11	82-mm mortar	1.3	Nose Down 45°	2.61
12	B-12	60-mm mortar	1.0	Flat	1.70
13	B-13	BDU 33	1.2	Flat	10.56
14	B-14	82-mm mortar	0.5	Nose Up 45°	2.61
15	B-15	82-mm mortar	2.0	Flat	2.50
16	B-16	82-mm mortar	1.0	Nose Up 45°	2.50
17	B-17	60-mm mortar	0.5	Nose Up 45°	1.73
18	B-18	60-mm mortar	0.25	Flat	1.73
19	B-19	Mk-19 practice bomb	1.0	Nose Up 45°	5.79
20	B-20	60-mm mortar	0.25	Nose Down 45°	1.73
21	B-21	82-mm mortar	0.8	Flat	2.61
22	B-22	60-mm mortar	1.2	Flat	1.70
23	B-23	81-mm mortar	1.5	Nose Up 45°	4.65
24	B-24	40-mm grenade	0.1	Flat	0.23
25	B-25	40-mm grenade	0.05	Flat	0.11
26	B-26	40-mm grenade	0.06	Flat	0.23
27	B-27	40-mm grenade	0.08	Flat	0.23
28	B-28	40-mm grenade	0.08	Flat	0.23
29	B-29	40-mm grenade	0.06	Flat	0.23
30	B-30	40-mm grenade	0.06	Flat	0.27
31	B-31	40-mm grenade	0.1	Flat	0.34
32	B-32	40-mm grenade	0.06	Flat	0.27
33	B-33	40-mm grenade	0.05	Flat	0.11

❖ mm millimeter  
❖ lb. pound

Figure 6-2 contains a map showing the locations of all targets. Appendix B contains pictures of the ordnance items aboveground prior to emplacement and pictures most of the ordnance items after emplacement, prior to backfilling.



## **6.3 Procedures**

The subsurface survey team was given the boundaries of the reference area and informed that 33 targets of various sizes and depths were located within the boundaries. They were not given any other data associated with the targets. The team then surveyed the area with the various sensors including the G858 Magnetometer, the EM61 sensor in the cart mode, and in the EM61 in the hand held mode. The procedures used for each sensor are outlined in the following sections.

### **6.3.1 G858 Magnetometer System**

The G858 magnetometer data was collected over the reference area using two sensors mounted on a wheeled cart. A base station was also utilized during the survey to measure the diurnal drift or variations in the earth's magnetic field. Quality assurance procedures included monitoring the battery, audio output and data collected during the survey to ensure integrity. The reference area data for the G858 magnetometer system was collected as total field corrected for diurnal variations.

### **6.3.2 EM61 Cart Mode**

The EM61 in the cart mode was used along survey lines spaced at 1 meter apart and at .2 meter intervals along the data lines. Quality assurance (QA) procedures included monitoring the battery, data logger/controller, and audio output during the survey to ensure data integrity. The system was also tested with a metallic test object placed on the surface prior to the actual survey of the reference area. After the survey the data was downloaded into the target analysis software for processing.

### **6.3.3 EM61 Hand Held Mode**

The EM61 HH was used along survey lines spaced at .5 meters apart and at .2 meters intervals along the data lines. The identical QA procedures as the EM61 cart mode were used to ensure data quality and integrity. After the survey the data was downloaded into the target analysis software for processing.

## **6.4 Results and Analysis**

Target analysis procedures were employed similar to the procedures used at the ATD sensor evaluations conducted by USAEC and NAVEODTECHDIV at the JPG. A circular area with a 1-meter radius was drawn around the center point of the target, representing the "detection zone" of that particular target. If the selected anomalies fell within the circle of the 1-meter radius, the target was reported as a true-

positive. The 1-meter critical radius circular detection areas and the selected anomalies for each sensor are presented in Figure 6-3. The G858 target selections are in red. The EM61 cart mode target selections are in magenta. The EM61 HH target selections are in green.

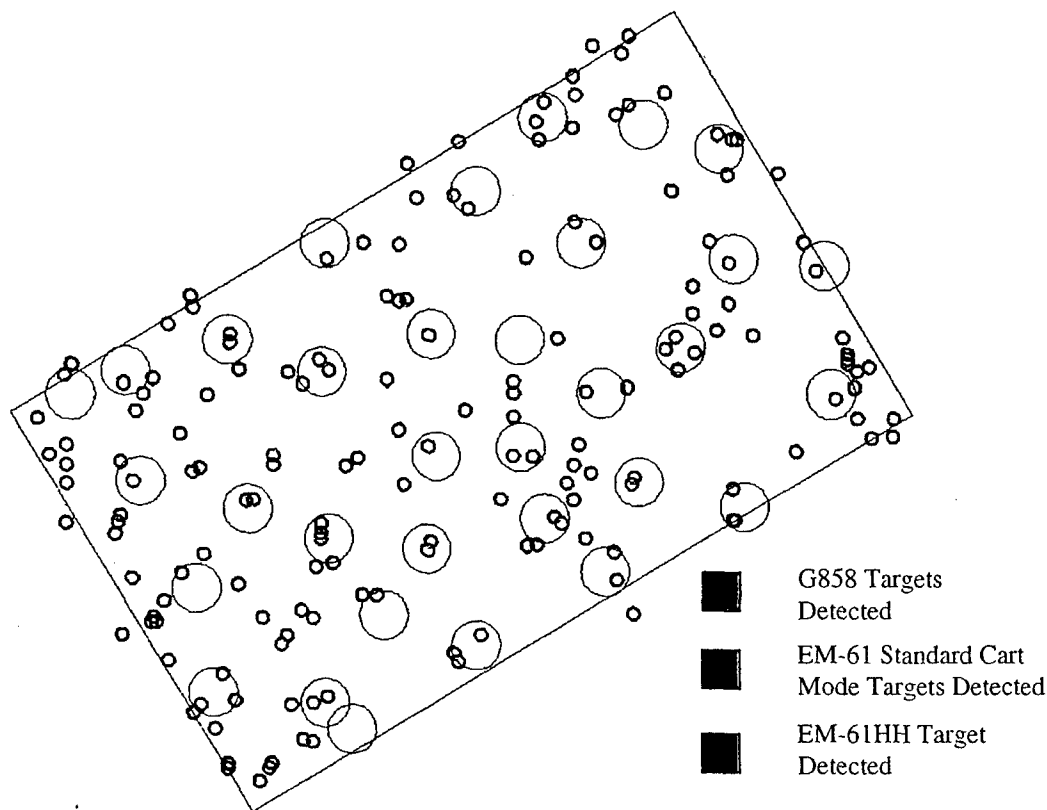


Figure 6-3 Reported Targets For Calibration Reference Area

The probability of detection ( $P_D$ ) for each sensor is computed by dividing the number of anomalies correctly selected over the total number of anomalies within the reference area.  $P_D$  for each sensor is presented in Table 6-2.

Table 6-2 Probability Of Detection

Sensor	Reported Targets	Correct Selections	Available Targets	False Alarm Ratio	Pd
G858 Mags	47	16	33	1.33	48.5%
EM61 Cart	50	22	33	1.51	69.7%
EM61 HH	77	23	33	2.33	66.7%

Each sensor reported a substantial number more selections than available targets or false alarms. False alarms are the target selections that were made that were not from ordnance items. The G858, EM61 cart and EM61 HH sensors reported a false alarm ratio (reported targets / ordnance detected or correct selections) of 1.94, 1.27, and 2.35 respectively. The EM61 cart mode showed the best overall statistics with the highest  $P_D$  and the lowest false alarm ratio. A further analysis of the reference area is covered in the report entitled, "Engineering Evaluation of UXO Detection Technologies and Interrogation Technologies for Use in Panama: Empire, Balboa West and Piña Ranges".

## 6.5 Conclusions

The EM61, in both cart and hand held modes, proved effective in locating most of the controlled targets, providing a detection rate of 69.7% and 66.7% respectfully. Although the probability of detection rates for the reference area were promising, a large amount of false alarms were reported. The false alarms may be attributed to the high amount of background noise or clutter associated with the local environment. The G858 passive magnetometry system did not fare as well as the active sensors, with only a 48.5%  $P_D$  rate but the data must be evaluated further. The magnetometer is only capable of detecting ferrous items and several of the targets did not contain any ferrous components (40 mm grenades). Therefore if the  $P_D$  is re-calculated without the non-ferrous targets the  $P_D$  rises to 60.9%. Even using the revised  $P_D$  values the EM61 configured in the cart mode had the highest probability of detection although the values from the other systems were very close (within 9%).

## **7.0 TECHNICAL ANALYSIS APPROACH USED AT EMPIRE, BALBOA WEST AND PIÑA RANGES**

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The UXO Assessment Report identified potential UXO areas on each of the three ranges and classified the areas into one of three major categories: 1) UXO AOCs, 2) suspect UXO AOCs and 3) areas of interest. UXO areas of concern were areas identified in the UXO Assessment Report that almost certainly contained UXO. The UXO AOCs were further evaluated with respect to potential UXO concentration levels. Five qualitative levels were defined including very-high, high, medium, low, and very-low. Suspect UXO AOCs were so designated because no direct evidence was found indicating they contain UXO. Instead, other factors such as topography, incident reports, or anecdotal information suggested that UXO might be present. UXO densities were not estimated for suspected UXO AOCs. The third major category is, areas of interest, were areas where either insufficient data was available to formulate conclusions regarding their UXO concentrations or they were unlikely to contain UXO.

SI information is provided for each Range AOC identified in the UXO Assessment Report including: background, SI activities, SI area results and area conclusion. The background information for each area investigated was taken from the initial UXO Assessment Report. All SI ordnance related activities are listed, including areas surveyed and technologies and methodologies employed. The results list the UXO, explosive ordnance (OE) scrap, non-OE scrap found, recovered and destroyed or removed and other anomaly data collected during the SI activities at each area. UXO is defined as ordnance which has been primed, fuzed, armed, or otherwise prepared for action, and which has been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material and remains unexploded either by malfunction or design or any other cause. The conclusion section presents the current status of each SI area as of 18 April 1998 based on the results of the SI activities. The areas listed in the UXO Assessment Report that were not part of the SI are not listed in this report, unless information or data was discovered during the SI that changed the original conclusions of the area. The SI information for Empire, Balboa West and Piña Ranges are presented in Sections 8, 9, and 10 respectively.

### **7.1 Fragmentation Analysis**

Where SI activities were conducted on locations that were outside of known impact areas (transects), a detailed analysis was conducted on the frag and ordnance related material discovered. The detailed analysis was necessary to determine the source and location of impact that could have caused the pieces

of fragmentation to appear at those survey points along the transect. This information becomes paramount because the analysis assists in indicating whether that area was once a former impact area (hence the potential for UXO), or the area was within travel range of fragmentation coming from a known impact area.

To analyze the fragmentation pieces found, technical manuals and computer modeling software were used, including "Fundamentals of Protective Design for Conventional Weapons, Headquarters, Department of the Army", Nov 1986, TM 5-855-1. The manual and accompanying software analyzes fragmentation data to determine the travel range for a particular piece of fragmentation. The fragmentation penetration vs. range analysis is discussed in the next section.

## **7.2 Fragment Penetration Versus Range**

Upon detonation of an explosive munition, the casing breaks up into a large number of fragments. In specially designed munitions, specifically missile warheads, fragment masses are controlled to certain weights, either by using preformed fragments or by causing the casing to break in a predetermined fashion. When the details of the munitions are known, the design fragment weight is easily determined. Most artillery shells, mortar rounds, and bombs however, have cases that fragment naturally; therefore determining a critical design fragment weight is more involved. Generally, the explosion of the naturally fragmenting munition will produce a comparatively large number of fragments. However, many of these are small and only larger fragments are considered in the design of protective structures since large fragments have the momentum necessary to perforate and damage. The penetration of small arms bullets, artillery projectiles, and aircraft bombs in materials other than concrete and steel is extremely variable. The variation in penetration into any one type of material results from the inconsistency of the material. It is extremely difficult, therefore, to fit the data into some general law of penetration for miscellaneous materials as a whole. Of the miscellaneous materials, the most resistant are certain types of hard stone, followed by brickwork, stabilized soil, gravel, sand, asphalt, and all kinds of soil. The penetration in the least-resistant soil may be five to ten times greater than that in stone.<sup>1</sup>

TM 5-855-1 presents equations that model the penetration depth vs. fragmentation range for varying parameters, including explosive weight, case material, diameter, shape and other characteristics of the munition as well as characteristics of the penetration medium including soil. The equations are not presented in the report but the program was used and the results of the modeling software are presented

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<sup>1</sup> TM 5-855-1

where applicable. The TM 5-855-1 fragmentation modeling results, depicted in a penetration vs. fragmentation range graph, provides an estimate of the travel distance for a particular piece of frag. When travel distance data is available, the origin of impact can be easily estimated by drawing a circle around the target location of the frag, with a radius equal to that of the travel distance of the frag itself. It becomes possible, therefore, to determine whether the area of concern was a former impact area, indicating the possibility of UXO, or whether the fragmentation could have come from a nearby impact area. For example if a piece of frag was located 350 meters from an impact area but the analysis determined that the frag traveled only 100 meters means that the point of impact (detonation point) occurred outside the impact area. Therefore, indicating the potential for UXO outside the impact area.

The fragmentation analysis software required detailed input such as fragmentation mass, penetration depth, and type of fragmentation. Therefore each piece of fragmentation recovered during the transect surveys was carefully documented. Appendix C provides the specifications and a picture of most of the transect targets recovered. Although detailed data was collected on the fragmentation certain assumptions were made during the analysis including that penetration occurred normal to the surface, all fragments were from high order explosions, and that the vegetation did not block or hinder the traveling fragment. Because of these gross assumptions the results of the fragmentation analysis were not used alone to draw conclusions about an area. Other characteristics about the area such as past knowledge, EOD reports, range police call reports, and the local characteristics of the area which are indicators of an impact area (range residue and craters) were used along with the fragmentation analysis results to draw conclusions of an area.

The UXO concentration levels were derived using the characterization methodology used in the earlier UXO Assessment report. The methodology assumes 5 levels to qualitatively estimate the number of UXO at each site. These levels included: very-high, high, medium, low and very-low. Generally, impact areas and targets were estimated to have very-high or high UXO density. For other UXO AOCs, the UXO density was estimated by evaluating (1) the location of the area relative to ordnance FPs and impact areas or targets and (2) the firing fan dimensions for specific ordnance types. The data collected during the SI provided ground truth to verify, validate or to refine the assumptions made in the original UXO Assessment report.

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## **8.0 SITE INVESTIGATION - EMPIRE RANGE**

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This section presents background (initial characterization), SI activities, SI results and conclusions about each UXO AOC, suspect UXO AOC and area of interest on the Empire Range that were affected by the SI. Areas listed in the UXO Assessment report that were not part of the SI activities are not listed in this section unless information or data was discovered during the SI that changed the characterization or conclusions of the area.

### **8.1 UXO Areas of Concern on The Empire Range**

The Empire Range UXO AOCs that were investigated during the SI include the following:

- Main Impact Area
- Range 6
- Range 1/1A Area
- EOD Range
- Camp Bayonet
- Firing Fan Associated with FP-11
- Firing Fan Associated with FP-15
- Firing Fan Associated with Range 19
- Range 18

These UXO AOCs are discussed in the following sections.

#### **8.1.1 Main Impact Area**

Below are the background, SI activities, SI results and SI conclusions for the Main Impact Area.

##### **Background – Initial Characterization**

The Main Impact Area is an irregular shaped, 600-hectare area in the southeast portion of the Empire Range. The northeast boundary of the Main Impact Area is within 1.5 km of the Panama Canal. About 30 percent of the Main Impact Area is located within the Canal Operating Area, and the rest of the Main Impact Area lies within a military area of coordination.

The Main Impact Area is a UXO AOC because the U.S. Army used nearby ranges and FPs to fire explosive ordnance into the Main Impact Area. According to range maps, USARSO Supplement 1 to AR 385-63, and USARSO Regulation 350-3, ordnance fired from FPs and ranges were aimed at targets within the Main Impact Area. Except for Range 8, exact target locations within the Main Impact Area could not be determined.

As evaluated in the initial UXO Assessment Report, most of the Main Impact Area is estimated to have high and very-high UXO densities. Central areas of the Main Impact Area are likely to have a very-high UXO density because most targets were located near the center of the Main Impact Area. Isolated areas with very-high UXO density in the northeast portion of the Main Impact Area represent hillside targets. The high-density areas within the Main Impact Area represent ordnance safety buffer zones. UXO density estimates for buffer zones were determined by considering the maximum ranges of ordnance fired at the area. The medium UXO density zone is defined by the maximum buffer zone for 81mm mortar projectiles. The low UXO density zone surrounding the medium UXO density zone is defined by the maximum buffer zone for 60mm mortar projectiles.

### **SI Activities**

SI activities within the Main Impact Area consisted of surface clearance and limited subsurface clearance within certain portions of the Main Impact Area. The areas effected by the SI include Range 7, Range 7A, Range 8, Range 10, K15 ROAD, and the base of the Cerro Marieta (see Map 8-1). Several factors were used to determine which areas to survey including: terrain, vegetation, ordnance expected, and safety. Vegetation removal methods used included slash and burning and automated or machine assisted cutting.

### **SI Results**

Approximately (859) UXO were removed from the Main Impact Area on various portions of the SI work areas. The general types of UXO removed from the Main Impact Area are listed below.



**Artillery Projectiles:** 20mm, 37mm, 75mm, 76mm, 105mm, 120mm, 6 inch, 155mm

**Mortar Projectiles:** 60mm, 81mm, 107mm

**Recoilless Rifle Projectiles:** 57mm, 90mm, 106mm

**Guided Missiles:** Dragon, TOW

**Rockets:** 2.36 inch, 35mm, 66mm LAW, 3.5 inch, SMAW, AT-4

**Projected Grenades:** 40mm, 84mm

**Submunitions:** M42

A special waiver, required by Army Policy, was obtained to work in an area containing the M42 submunitions. M42 submunitions are very hazardous ordnance, which are typically deployed from a 155mm improved conventional munitions (ICM) round that carries 180 M-42 submunitions as payload.

In addition to the UXO removed from the Main Impact Area over (10) tons of Ordnance and Explosive (OE) contaminated scrap and 50 Tons of non-OE scrap was removed from the Main Impact Area. Included in the non-OE scrap are old range targets that were removed as shown in Figure 8-1.

## **SI Conclusions**

The Main Impact Area of Empire was classified in the UXO Assessment Report as having high to very-high UXO concentration levels throughout. The initial report also indicated the potential for artillery projectiles, mortar projectiles, recoilless rifle projectiles, guided missiles, rockets, projected grenades, and submunitions, which were all found during the SI. Based on the types and amounts of UXO that has been removed from the area and the potential for more UXO to be there confirms the findings of the original assessment report where the Main Impact Area contains very-high to high amounts of UXO submunitions.



**Figure 8-1 Non-OE Scrap Including Old Range Targets Removed From The Empire Range**

#### **8.1.2 Range 6 Area**

Below are the background, SI activities, SI results and SI conclusions for the Range 6 Area.

##### **Background – Initial Characterization**

At Range 6, mortar and artillery ordnance was fired at targets located outside and north of the Main Impact Area. The recoilless rifles fired directly at dedicated targets located within the Range 6 small-arms range. Explosive ordnance used on Range 6 includes small arms and 40mm. Between 1981 and 1984, nonstandard live-fire range operations at Range 6 were authorized to deploy 40mm Target Practice (TP) and High Explosive (HE) ammunition, 60mm HE mortar shells, and 90mm Canister (CAN) and High Explosive Anti-tank (HEAT) recoilless rifle ammunition.

The initial UXO density reported within this firing fan varied from high to low. The area nearest the FP was estimated to have a high UXO density because of (1) the use of ordnance with relatively short maximum firing distances, such as 40mm projected grenades; and (2) short-fired rounds resulting from the use of ordnance with relatively long firing distances, such as 81mm and 107mm mortar shells. The high UXO density area was defined by the range of 40mm projected grenades and may also contain short-fired mortar, rocket, and recoilless rifle rounds. The medium UXO density area may contain unexploded mortar, rocket, and recoilless rifle rounds. The low UXO density area may contain unexploded mortar and recoilless rifle rounds.

### **SI Activities**

There were no SI activities conducted at this site because of recent events in the area which are covered in the SI conclusions below.

### **SI Results**

NA – See SI conclusions below.

### **SI Conclusions**

SI activities were not conducted at the Range 6 area because recent events have changed the character of the area. Spoil material from the Gaillard Cut widening project has been dumped on the area formerly known as Range 6 (Map 8-1). The spoil mound measures approximately 37.55 hectares in size, is 20 meters high in some places and continues to grow as the widening project progresses (see Figure 8-2). The large amounts of fill material placed over the Range 6 area make it technologically impossible to locate and recover any buried UXO that may exist there.



**Figure 8-2 Range 6 (Spoil Dump Area for Canal Widening Project)**

If technology is not available to locate and recover buried UXO to previous levels the potential surface effects from an explosion need to be examined to ensure safe overburden distances are maintained. As explosives are detonated at increasing depths below the surface of the ground, there's a point at which the explosion is not forceful enough to vent or seriously disrupt the ground surface. The distance below the surface required to obtain the explosion is a function of the density of the fill material above the UXO and the weight of the explosive material contained in the specific ordnance where  $D$  = is the depth in feet (ft.), and  $W$  = weight of the explosives in pounds (lbs.).

The safe earth fill distance is based on the formula:

$$D = 3.5(W)^{1/3}$$

The formula assumes an average unit weight (density) of soil to be 100 pounds per cubic foot. Straight line factoring can be used to account for other soil or fill densities (i.e., the distance for a sanitary fill of 50 lbs./ft<sup>3</sup> would be double that obtained by the formula. The type of explosive material contained within an ordnance item has little if any effect on the safe earth distance. Demolition principles indicate that the

expansive effect of an internal charge (ordnance) depends primarily on the amount of gas produced during the explosion. This is a function of the explosive quantity and not the explosive type.

In the case of Range 6 if an explosion were to occur from a 106mm round (the largest item reported at that location) the minimum safe overburden distance can be calculated.

Item: 106mm Recoilless Rifle Round

Net Explosive Wgt.: 7.72 lbs

D = 6.9 ft (2.10 meters)

Since the overburden from the canal widening project ranges from 6-20 meters in most places the critical safe overburden depth is greatly exceeded, with a factor of safety of 2.85 – 9.50. Using this formula, the surface would not be disturbed if an underground explosion occurred in most places of the Range 6 canal widening overburden area. In addition, end land uses down to the critical depth are not conceivable for that area. Therefore, although UXO may exist within the area, it has been eliminated from the UXO concentration overlays and is not discussed further.

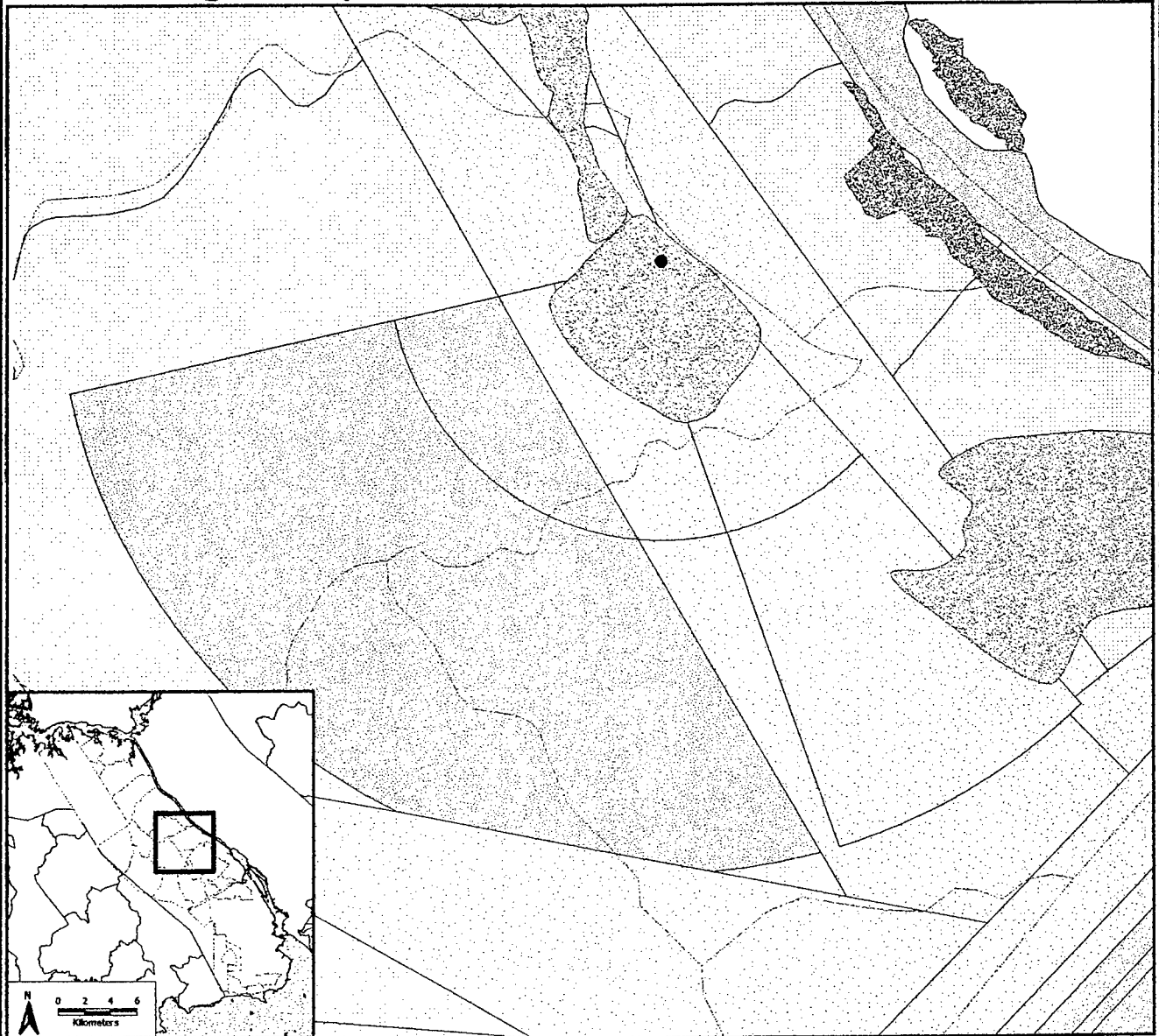
### **8.1.3 Range 1/1A Area**

Below are the background, SI activities, SI results and SI conclusions for the Range 1/1A Area.

#### **Background – Initial Characterization**

Range 1/1A has been used as a small-arms range to train military personnel to fire M-16 and M-14 rifles and M-2 machine guns since at least 1978. Range 1/1A is currently not authorized for explosive ordnance use. Range 1/1A Area is a UXO AOC because several UXO items have been recovered in the past, while target renovations have taken place in the vicinity, including (15) 3-inch Stokes mortar shells, a 107mm smoke mortar projectile and a 3.5-inch WP rocket. Range 1/1A Area was estimated to have a medium UXO density because it is likely a former impact area and may contain HE and WP rounds as well as TP ammunition.

# Range 6 Spoil Material From Gaillard Cut



## Legend

- Firing Points
- ▨ Disposal Area (Planned)
- ▩ Disposal Area (Used)
- ▧ Excavation Area
- ▭ Training Areas
- Initial UXO Concentrations
- ▨ Very High UXO Concentration
- ▩ High UXO Concentration
- ▧ Medium UXO Concentration
- ▭ Low UXO Concentration
- ▨ Very Low UXO Concentration
- ▩ Suspected UXO Concentration
- ▧ No Known UXO Concentration

Map Not To Scale

## Empire



0 250 500 750 1000  
Meters

Map 8-2 Range 6 Spoil Material From Gaillard Cut

## **SI Activities**

SI activities included random grid sampling for surface and subsurface UXO. Three 50' x 50' grids were randomly selected and sampled with a Mk-26 Ferrous Ordnance Locator within the Range 1/1A area.

## **SI Results**

A total of (8) anomalies were located within the three sample grids but none were UXO or ordnance related scrap.

## **SI Conclusions**

Sampling has occurred in the area and no UXO or other significant items were located. Although UXO may be present there the area has been eliminated from the UXO AOC list because no known UXO exist there.

### **8.1.4 Explosive Ordnance Disposal Range Area**

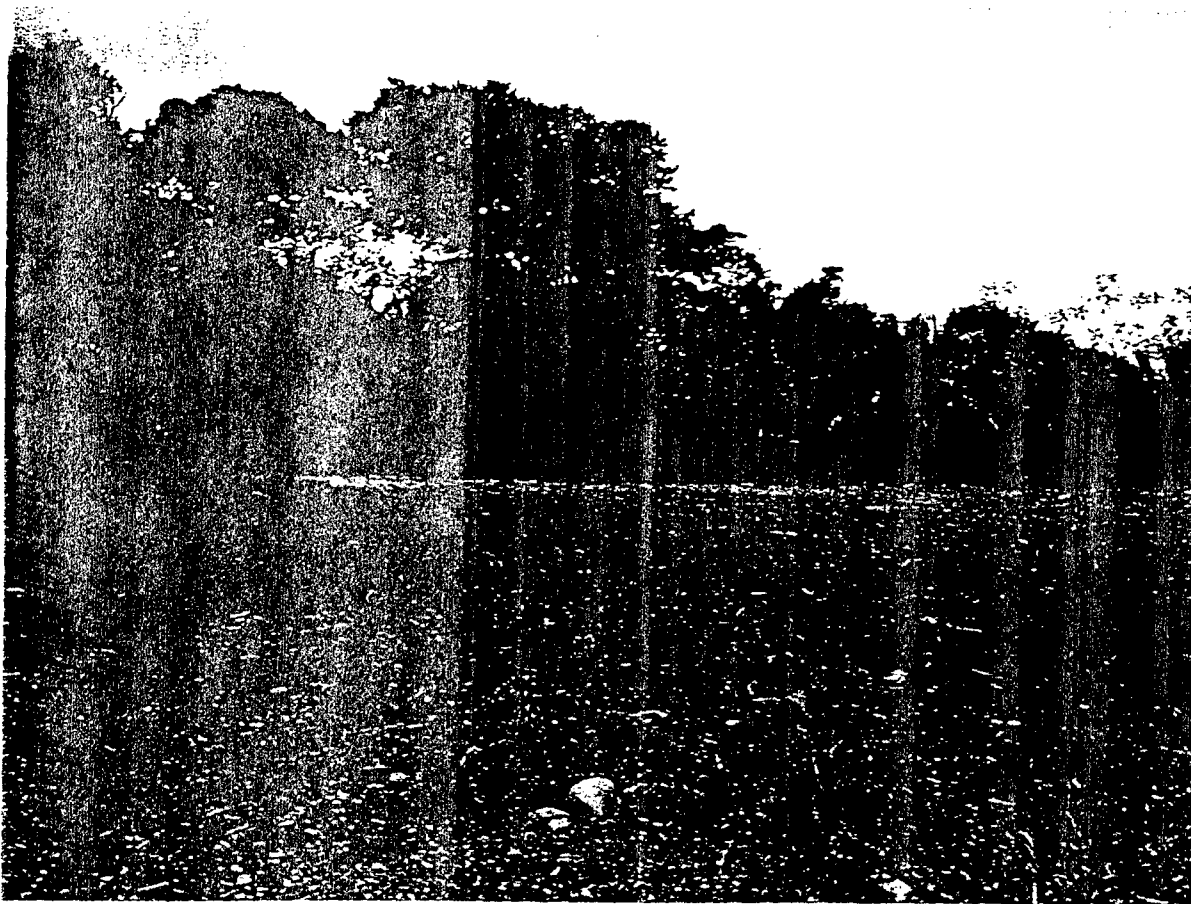
Below are the background, SI activities, SI results and SI conclusions for the Explosive Ordnance Disposal Range Area.

#### **Background – Initial Characterization**

The EOD Range was used to dispose of "unserviceable and hazardous ammunition." Disposal typically consists of placing the unserviceable ordnance in a hole, covering the ordnance with soil, and detonating the buried ordnance. EOD Range use varied according to the volume of unserviceable ammunition generated. The disposal procedures used would have influenced the type and concentrations of UXO at the EOD Range. The center of the EOD Range is likely to have a high UXO density that decreases with distance from the center. The high UXO density area is a 200-meter-diameter, circular area around the center of the range. The medium UXO density area extends outward an additional 200 meters from the high UXO density area. These areas define the probable extent of UXO kickout buffer based on U.S. Army range safety regulations. USARSO Regulation 350-3 specifies a 730 meter-radius kickout zone measured from the center of the EOD Range; therefore, UXO is suspected to be present in that area.

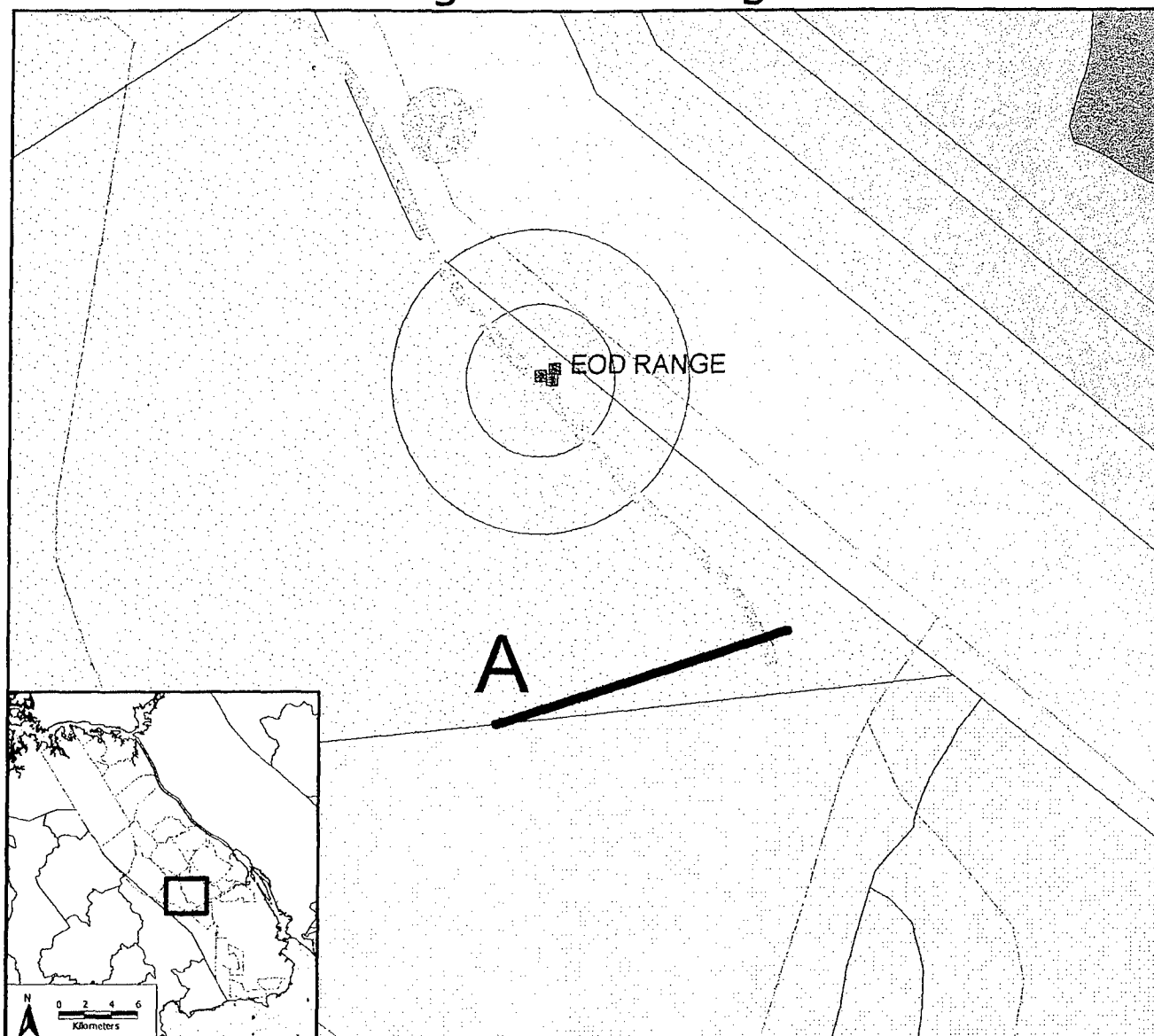
## **SI Activities**

SI activities conducted on the EOD Range Area consisted of surface sweeping the accessible areas of the EOD Range and a 351 meter long subsurface transect survey in the suspected buffer zone. The surface sweep was conducted after the accessible areas were cleared of high grass and vegetation using the All Purpose Remote Transport System (ARTS) vehicle. The area was surface swept and a bulldozer was brought in to grade and level the area. The transect was surveyed with a hand held EM61 locator starting off the K-6 road about 1,000 meters from the EOD range and progressing 351 meters toward the center of the EOD range in the buffer zone. Appendix D lists the details of transect A. The areas covered in the SI are shown in Map 8-3.



**Figure 8-3 Graded EOD Range**

## EOD Range Site Investigations

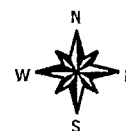


### Legend

- Firing Points
- Surface Sweep and Subsurface Characterization (Transect)
- Surface Sweep and Subsurface Characterization (Area)
- Surface Sweep
- Training Areas
- New UXO Concentrations
  - Very High UXO Concentration
  - High UXO Concentration
  - Medium UXO Concentration
  - Low UXO Concentration
  - Very Low UXO Concentration
  - Suspected UXO Concentration
  - No UXO Concentration

Map Not To Scale

### Empire



0 100 200 300  
Meters

Map 8-3 EOD Range Site Investigations

## SI Results

A total of (76) UXO items, 4,055 lbs of OE scrap, and 3,500 lbs of non-OE scrap were removed during the surface sweep effort. Table 8-1 lists types of UXO removed from the surface of the accessible areas of the EOD Range. Two anomalies were located and interrogated on the 351 meter transect survey located in the buffer zone of the EOD Range. One target was rock and the other was frag.

**Table 8-1 UXO Removed From The EOD Range**

UXO Type	Quantity
40 mm	1
105 Illun	1
3" Stokes	39
BDU 33	31
22 mm Sub-Cal TP	1
105 mm HE	2
Grenade Body	1

Ordnance Related Scrap 4,055 lbs

Non-Ordnance Related Scrap 3,500 lbs

## SI Conclusions

The accessible areas of the EOD Range were surface cleared of UXO and range debris (ordnance and non-ordnance related). The area was graded and surface scraped, but was not subsurface cleared so the possibility of subsurface UXO still exists. In addition the EOD range is still active and has been used since the surface sweep, so the potential for additional surface and subsurface UXO resulting from recent usage exists. Because of the limited number of anomalies located during the transect survey the suspect 730 meter buffer zone has been removed from the suspect UXO areas. However, the circular areas drawn from the center of the EOD remains classified as a high and medium UXO concentration levels accordingly.

### 8.1.5 Firing Fan for Firing Point 15 Area

Below are the background, SI activities, SI results and SI conclusions for the Firing Fan Area for FP 15.

## **Background – Initial Characterization**

FP 15 is a former 105mm Howitzer FP located on a flat hilltop near the east corner of training area 51. The firing fan area which is between FP 15 and the Main Impact Area was classified having a very-low UXO concentration level because of the potential for short-fired 105mm Howitzer projectiles.

## **SI Activities**

SI activities conducted on the firing fan area for FP-15 consisted of a 502 meter long subsurface transect survey (see Map 8-4). The transect (E) was surveyed with a hand held EM61 locator starting from FP and working towards the Main Impact Area of Empire. An additional 1,500 meters were visually surface swept along the same bearing as the subsurface transect survey.

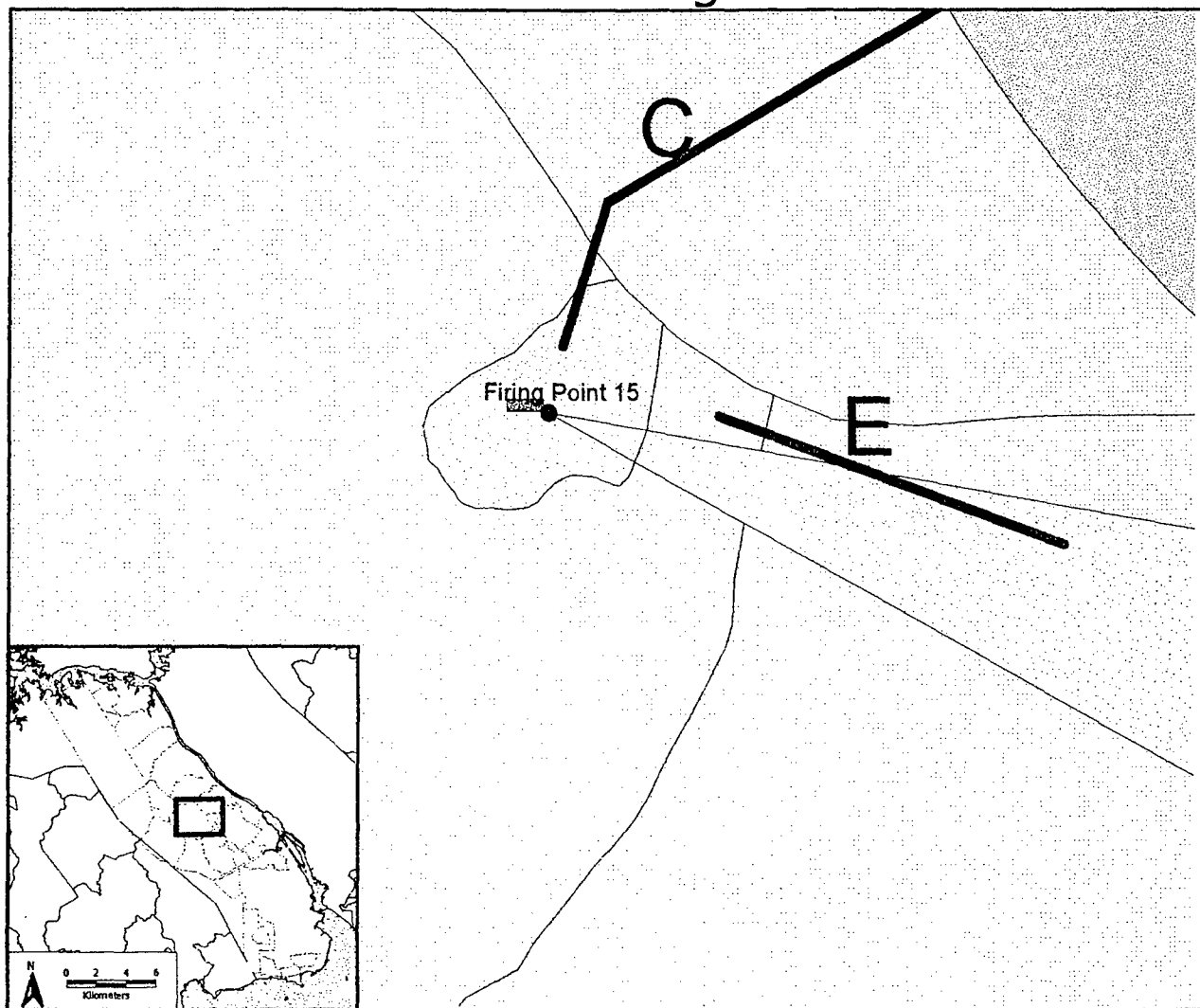
## **SI Results**

A total of (15) targets were detected and interrogated on the 502 meter, 8 segment, subsurface transect surveyed (transect E). Of the (15) targets found (10) targets were magnetic rock, (3) were non-ordnance related scrap, (1) was frag and (1) was un-relocatable. The frag was found in the 2<sup>nd</sup> segment of the transect less than .25 meters deep. Appendix D lists the transect and target data for FP-15 firing fan transect E and Appendix C provided details on some of the targets recovered.

## **SI Conclusions**

The surface and subsurface transect data did not indicate any significant evidence proving the presence of UXO within the firing fan. Therefore, although a small possibility of UXO exists for short rounds the area has been eliminated as a UXO AOC based upon the results of the SI and because no known UXO exist there. FP-15 is not included in the 1995 Range Regulations and has not been used for several years.

## Transect E at Firing Point 15

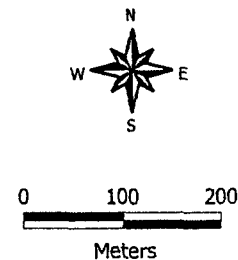


### Legend

- Firing Points
- Surface Sweep and Subsurface Characterization (Transect)
- ▨ Surface Sweep and Subsurface Characterization
- ▨ Surface Sweep
- Initial UXO Concentrations
  - ▨ Very High UXO Concentration
  - ▨ High UXO Concentration
  - ▨ Medium UXO Concentration
  - ▨ Low UXO Concentration
  - ▨ Very Low UXO Concentration
  - ▨ Suspected UXO Concentration
  - ▨ No Known UXO Concentration

Map Not To Scale

### Empire



Map 8-4 Transect E At Firing Point 15

### 8.1.6 Camp Bayonet Area

Below are the background, SI activities, SI results and SI conclusions for the Camp Bayonet Area

#### Background – Initial Characterization

The Camp Bayonet Area may have been used as a bombing range and as an ammunition destruction site in the past, but the dates of such activities are unknown. The Camp Bayonet area is estimated to have a medium UXO density because a significant number of bomb dummy unit (BDU)-33 practice bombs may be present in this area. Numerous BDU-33 practice bombs have been sighted and recovered in the Camp Bayonet area over the years.

#### SI Activities

SI activities conducted on the Camp Bayonet Area consisted of surface and subsurface sampling efforts. Three 50' x 50' grids and one 351 meter long transect were surveyed in the Camp Bayonet area. Technologies used include the Mk 26 Ferrous Ordnance Locator and the hand held EM61 all metals locator. The areas covered are shown in Map 8-5.

#### SI Results

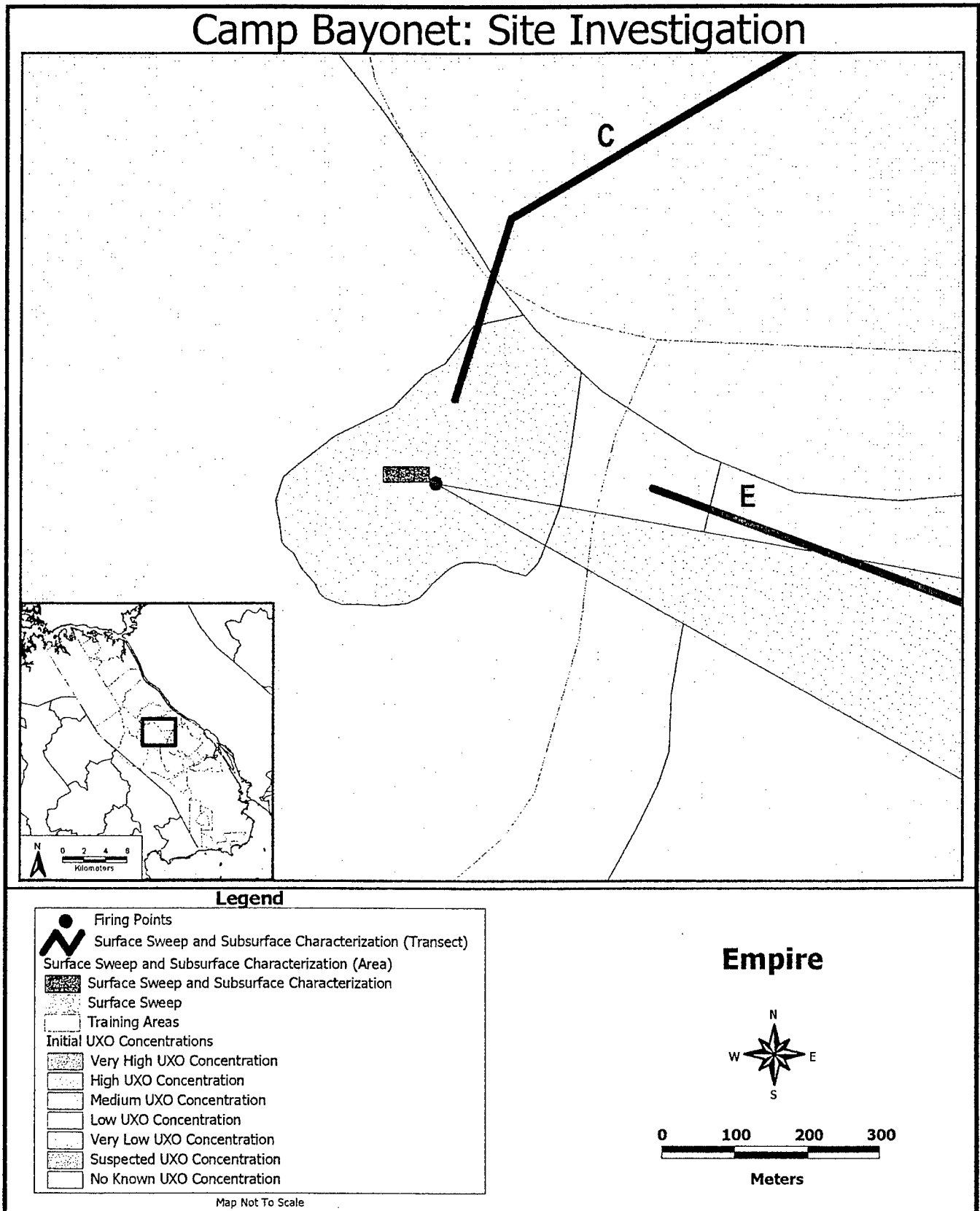
A significant amount of UXO (29) items were recovered in the limited sample area surveyed. The quantities and types of UXO discovered in the Camp Bayonet area during the SI are listed in Table 8-2 below. In addition a large portion of ordnance related scrap was discovered and removed from the area during the SI activities.

Table 8-2 UXO Removed From The Camp Bayonet Area

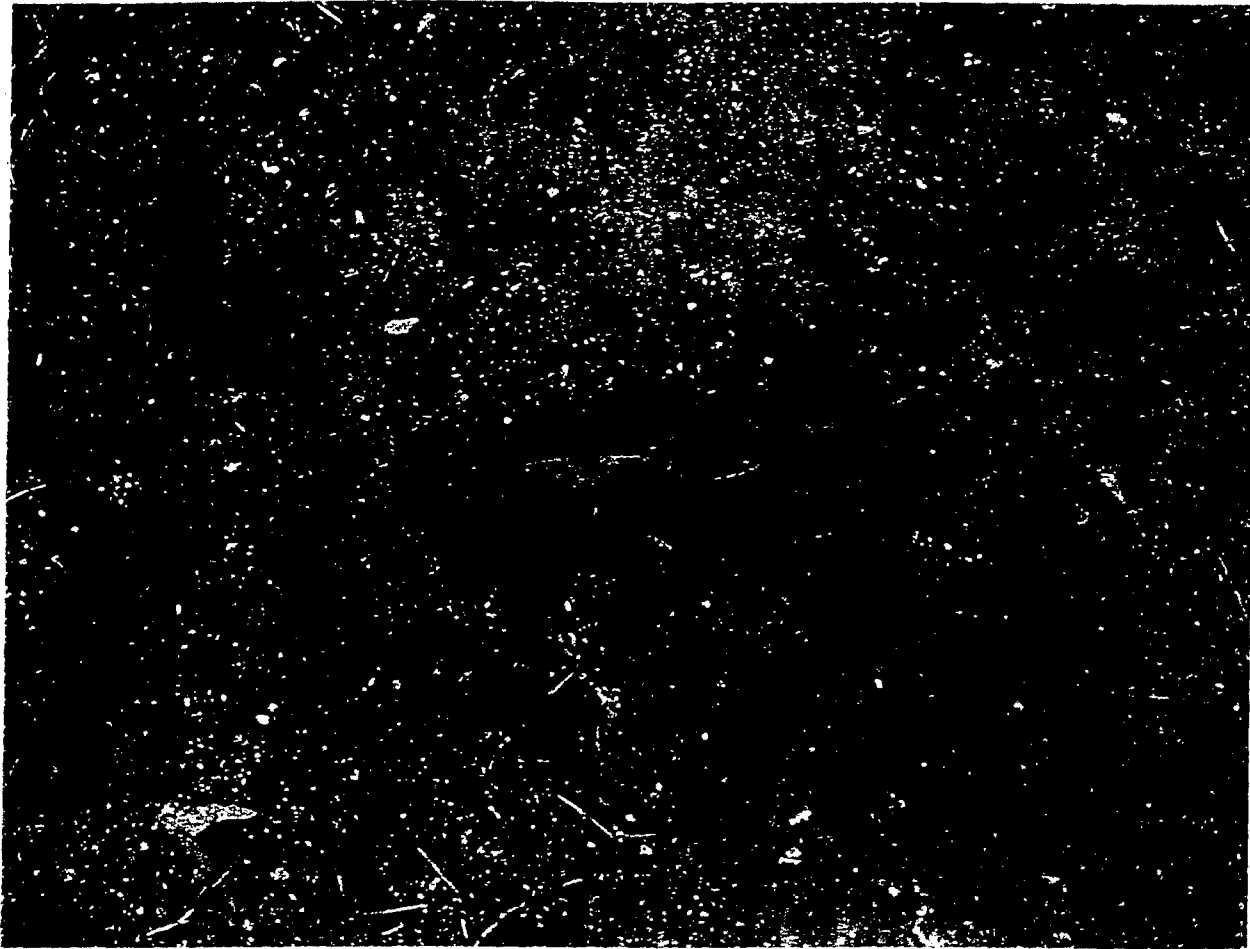
UXO Type	Quantity
BDU33	26
90mm Cartridge	1
37mm	1
40mm	1

Ordnance Related Scrap 313 lbs  
Non-Ordnance Related Scrap 120 lbs

# Camp Bayonet: Site Investigation



Map 8-5 Camp Bayonet: Site Investigation



**Figure 8-4 BDU 33 Recovered At The Camp Bayonet Area**

### **SI Conclusions**

The large amount of UXO items and related scrap that was discovered in the sampling areas on Camp Bayonet indicates that the entire area probably contains a large amount of UXOs. Based upon the results of the SI activities conducted in this area, the Camp Bayonet Area has been elevated to a high UXO concentration level. No other sampling or removal actions have been conducted in the Camp Bayonet area.

### **8.1.7 Firing Fan for Firing Point 11 Area**

Below are the background, SI activities, SI results and SI conclusions for the Firing Fan are of FP 11 Area.

## **Background – Initial Characterization**

FP 11 is a former Mortar and Howitzer FP located on a flat hilltop near the east corner of TA 51. The firing fan area between the FP and the Main Impact Area was classified as having a very-low UXO concentration level because of the potential for short-fired 105mm Howitzer projectiles. The 1995 USARSO Regulation authorizes 60mm, 81mm and 107mm mortars to be fired from that location.

## **SI Activities**

SI activities conducted on the firing fan area for FP-11 consisted of a 368 meter subsurface survey transect. The transect was surveyed with a hand held EM61 locator starting from the K-6, K-15 road intersect working toward the Main Impact Area of Empire Range. Map 8-6 shows the transect area surveyed.

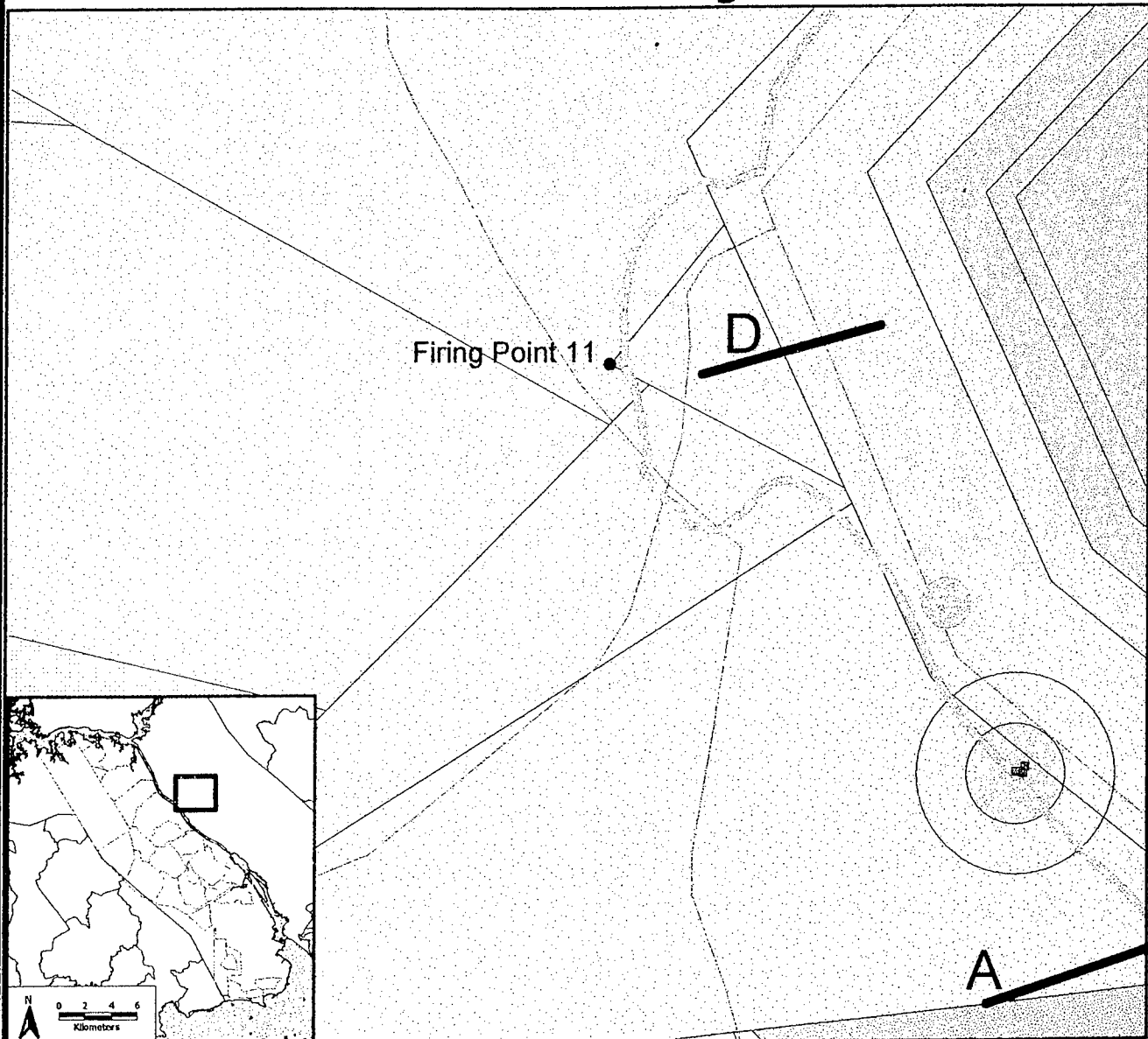
## **SI Results**

A total of (10) targets were detected and interrogated on the 368 meter, 8 segment, subsurface transect survey (transect D). Of the (10) targets discovered (4) targets were magnetic rock, (3) were geologic noise, (2) were frag and (1) was un-relocatable. The frag was found in the 2<sup>nd</sup> and 4<sup>th</sup> segments respectively, less than .25 meters deep. The 1 target which was un-relocatable had a very-low detector response rate and was determined to be as small as a shell from a small arms round. Appendix D lists the transect and target data for Transect D, FP-11 firing fan area. Appendix provides detailed data on some of the targets recovered during the transect survey.

## **SI Conclusions**

A penetration depth vs. distance analysis was conducted for each of the two pieces of frag detected on the transect. The results are shown in Tables 8-3 and 8-4. Both travel distances, 415 meters and 442 meters respectively fall within the range of the Main Impact Area. Since no other evidence was found indicating the presence of UXO in the firing fan area this area has been eliminated from the UXO AOC list.

# Transect D at Firing Point 11

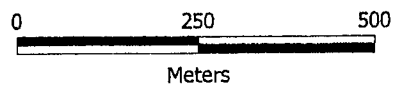
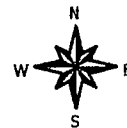


## Legend

- Firing Points
- Surface Sweep and Subsurface Characterization (Transect)
- Surface Sweep and Subsurface Characterization
- Surface Sweep
- Training Areas
- Initial UXO Concentrations**
- Very High UXO Concentration
- High UXO Concentration
- Medium UXO Concentration
- Low UXO Concentration
- Very Low UXO Concentration
- Suspected UXO Concentration
- No Known UXO Concentration

Map Not To Scale

## Empire



Map 8-6 Transect D At Firing Point 11

Table 8-3 Fragmentation Penetration Depth Versus Distance

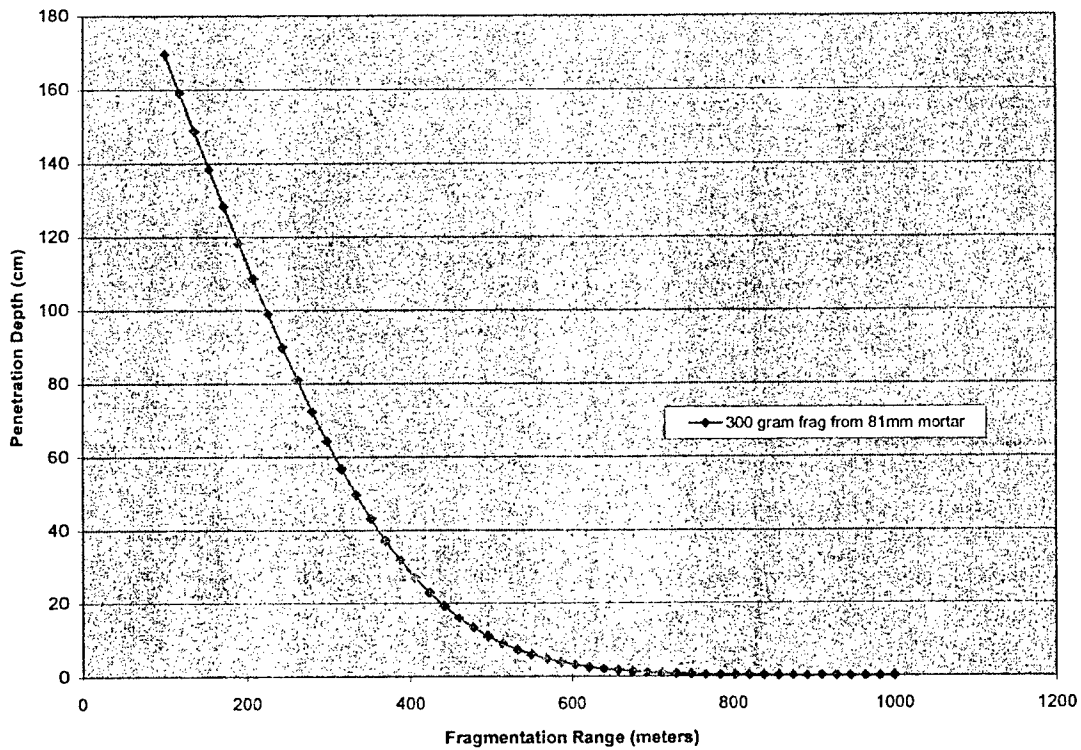
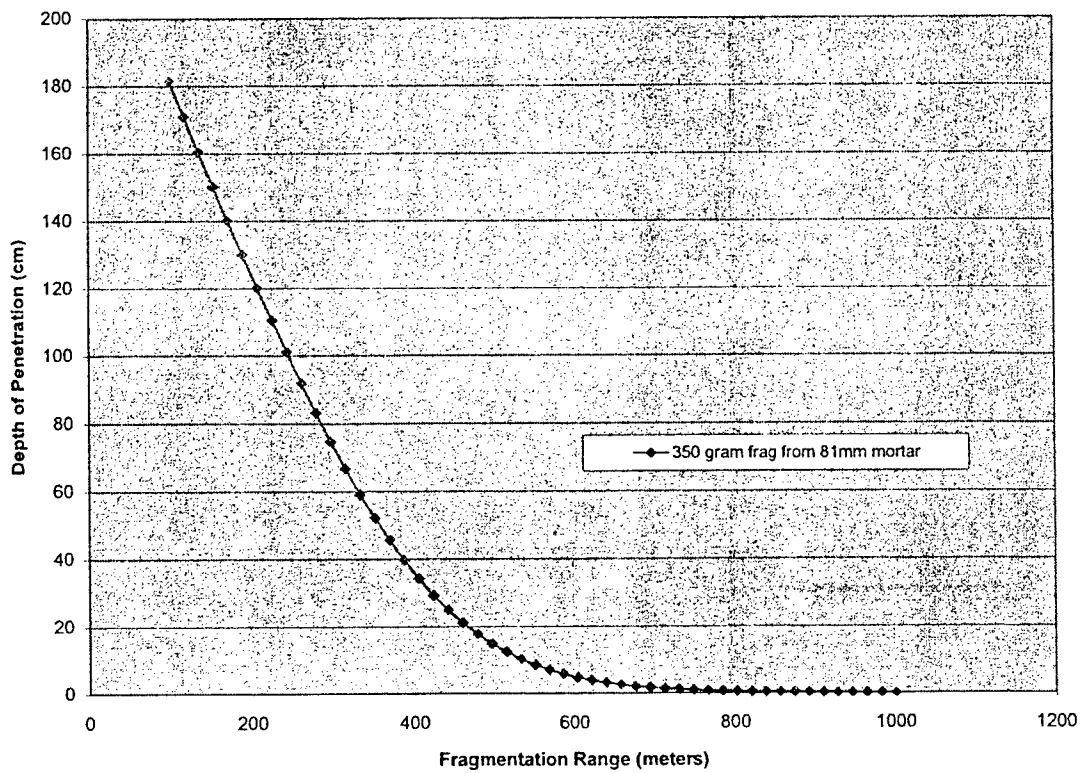


Table 8-4 Fragmentation Penetration Depth Versus Distance



### **8.1.8 Firing Fan for Range 19 Area**

Below are the background, SI activities, SI results and SI conclusions for the Firing Fan for Range 19 Area.

#### **Background – Initial Characterization**

The firing fan area for Range 19 between the FP and the Main Impact Area was classified as having a UXO concentration level of very-low because of the potential for short-fired ordnance.

#### **SI Activities**

SI activities conducted on the firing fan area for Range 19 consisted of a 742 meter long subsurface transect survey. The transect (B) was surveyed with a hand held EM61 (see Figure 8-5) locator starting from the top of Range 19 and working toward the Main Impact Area of Empire. Map 8-7 shows the area surveyed.

#### **SI Results**

Two targets were detected in the 742 meter long, 11 segment transect. Both targets were magnetic rock. After the targets were removed the areas were re-surveyed to ensure multiple targets did not exist there.

#### **SI Conclusions**

During the SI no evidence was discovered which indicated the presence of surface or subsurface UXO concentrations. Therefore, the firing fan area for Range 19 has been eliminated from the list of UXO areas of concern.



**Figure 8-5 Range 19 Firing Fan Area Survey With EM61 HH**

#### **8.1.9 Range 18 Area**

Below are the background, SI activities, SI results and SI conclusions for the Range 18 Area.

##### **Background – Initial Characterization**

Range 18 is a relatively new range that USARSO has opened in order to continue weapons familiarization and proficiency training during the range closure process since certain ranges have been closed for training. Range 18 is set up as a multi-purpose range where the following types of ordnance are authorized for use: 40mm, AT-4 and LAW. The range is located within the Main Impact Area of Empire and is shown in Map 8-7.

##### **SI Activities**

There were no SI activities conducted in this area, however range maintenance activities were conducted in the area, which provides additional information on UXO concentrations on the Empire Range. New targets were emplaced on Range 18, which required ground EOD support during the vegetation and target placement activities.

## **SI Results**

During the range maintenance operations (15) UXO items were located and removed; in addition M-39 submunitions were found in the area. M-39 submunitions are very hazardous anti-personnel ordnance, which are typically deployed from 105mm ICM round that carries (18) M-39 submunitions as payload.

## **SI Conclusions**

The Range 18 area lies within the Main Impact Area of Empire, which was classified in the UXO Assessment Report, as having high to very-high UXO concentration levels throughout. Based on the types and amounts of UXO that have been removed from the area, it is expected that this area is indeed highly contaminated with UXO including M-39 submunitions. The exact extent of the concentrations of submunitions is unknown.

## **8.2 Suspect UXO Areas Of Concern On The Empire Range**

This section describes areas that are suspected to contain UXO. These areas were not designated as UXO AOCs because no direct evidence was found indicating that they contain UXO; instead, indirect evidence or anecdotal information suggests that UXO may be present. In each case, insufficient information was found to reasonably estimate the UXO density and hazard level.

Suspect UXO AOCs that were investigated on Empire during the SI include the following:

- Rio Fuentes Washout Area And Rio Grande Washout Area
- Range 6 Potential Impact Area

These suspect UXO AOCs are discussed in the following sections.

### **8.2.1 Potential Rio Fuentes and Rio Grande Washout Areas**

Below are the background, SI activities, SI results and SI conclusions for the Potential Rio Fuentes and Rio Grande Washout Areas.

## **Background – Initial Characterization**

Washout areas are areas where surface soil and debris are subject to transport and accumulation as a result of runoff and erosion processes. The Rio Fuentes and Rio Grande Washout Areas are suspected to contain UXO because of the likelihood that UXO has migrated to this area from the Main Impact Area. The Rio Fuentes area surveyed is shown in Map 8-7.

## **SI Activities**

SI activities included a visual survey and surface sweep of the Rio Fuentes and Rio Grande washout areas. The survey personnel were aided in the visual search with a Schonstedt Locator.

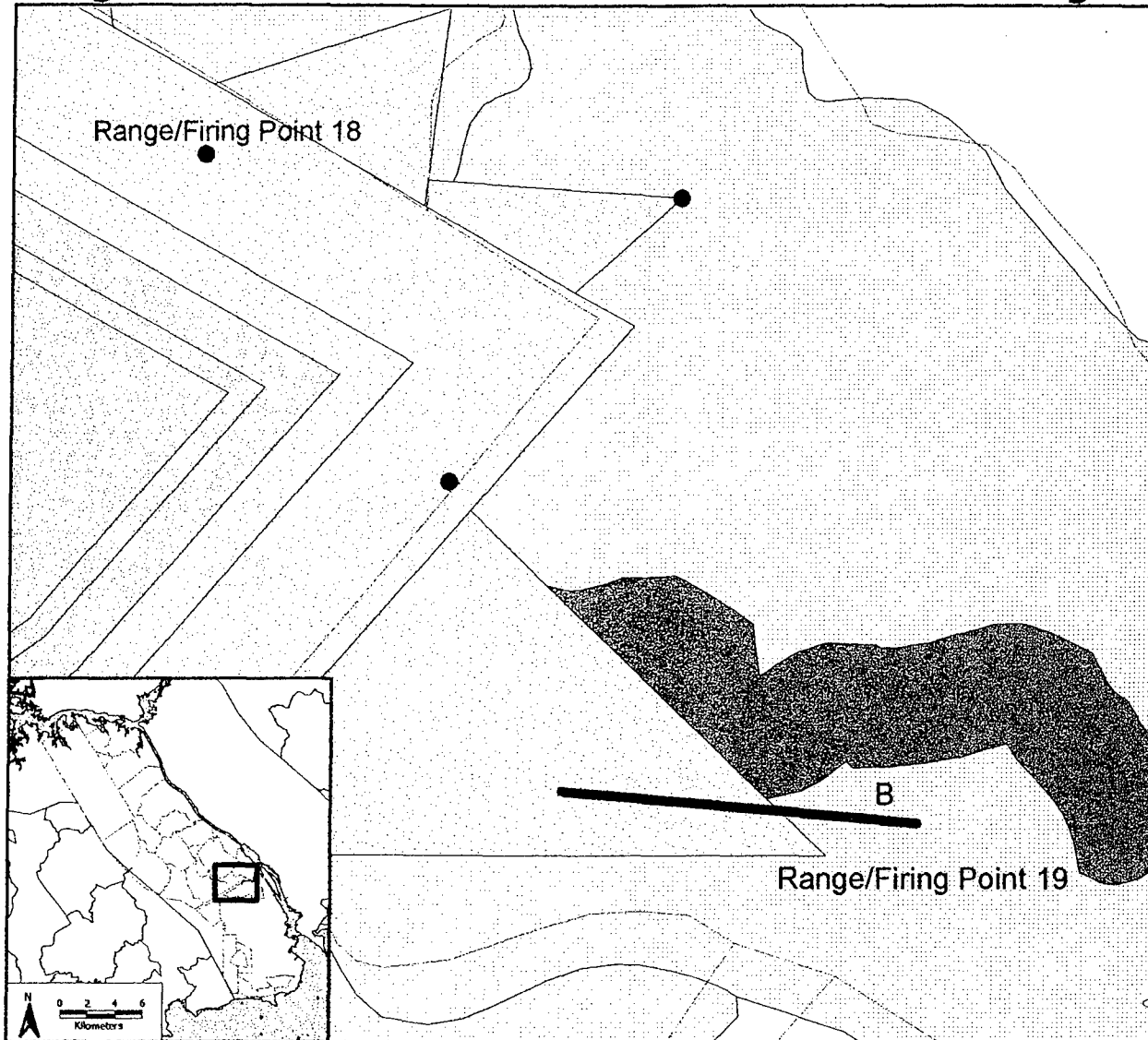
## **SI Results**

No ordnance or ordnance related materials were discovered on or near the surface of the washout area. All of the anomalies located by the Schonstedt were surface or near surface rocks.

## **SI Conclusions**

The streambed was not covered by vegetation and visibility was excellent. Since no ordnance or ordnance related items were recovered from, or seen in the washout areas. They have been eliminated from the list of suspect AOC areas.

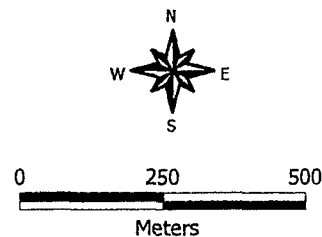
# Range 19 and Rio Fuentes Washout Area Site Investigation



## Legend

- Firing Points
- Surface Sweep and Subsurface Characterization (Transect)
- Surface Sweep and Subsurface Characterization
- Surface Sweep
- Training Areas
- Initial UXO Concentrations**
  - Very High UXO Concentration
  - High UXO Concentration
  - Medium UXO Concentration
  - Low UXO Concentration
  - Very Low UXO Concentration
  - Suspected UXO Concentration
  - No Known UXO Concentration

## Empire



Map Not To Scale

Map 8-7 Range 19 And Rio Fuentes Washout Area Site Investigation

### **8.2.2 Range 6 Suspect Impact Area**

Below are the background, SI activities, SI results and SI conclusions for the Potential Range 6 Impact Area.

#### **Background – Initial Characterization**

The Range 6 suspect impact area is where the firing fan associated with Range 6 possibly existed over the years. The suspect impact area is where an UXO incident involving a 90mm recoilless rifle round occurred, resulting in the death of one Panamanian civilian and serious injury to another.

#### **SI Activities**

SI activities conducted on the suspect impact area for Range 6 consisted of a 929.9 meter long subsurface transect survey. The transect was surveyed with a hand held EM61 locator starting from the top of the Camp Bayonet area and working towards the suspect impact area of Range 6. Map 8-8 shows the area surveyed.

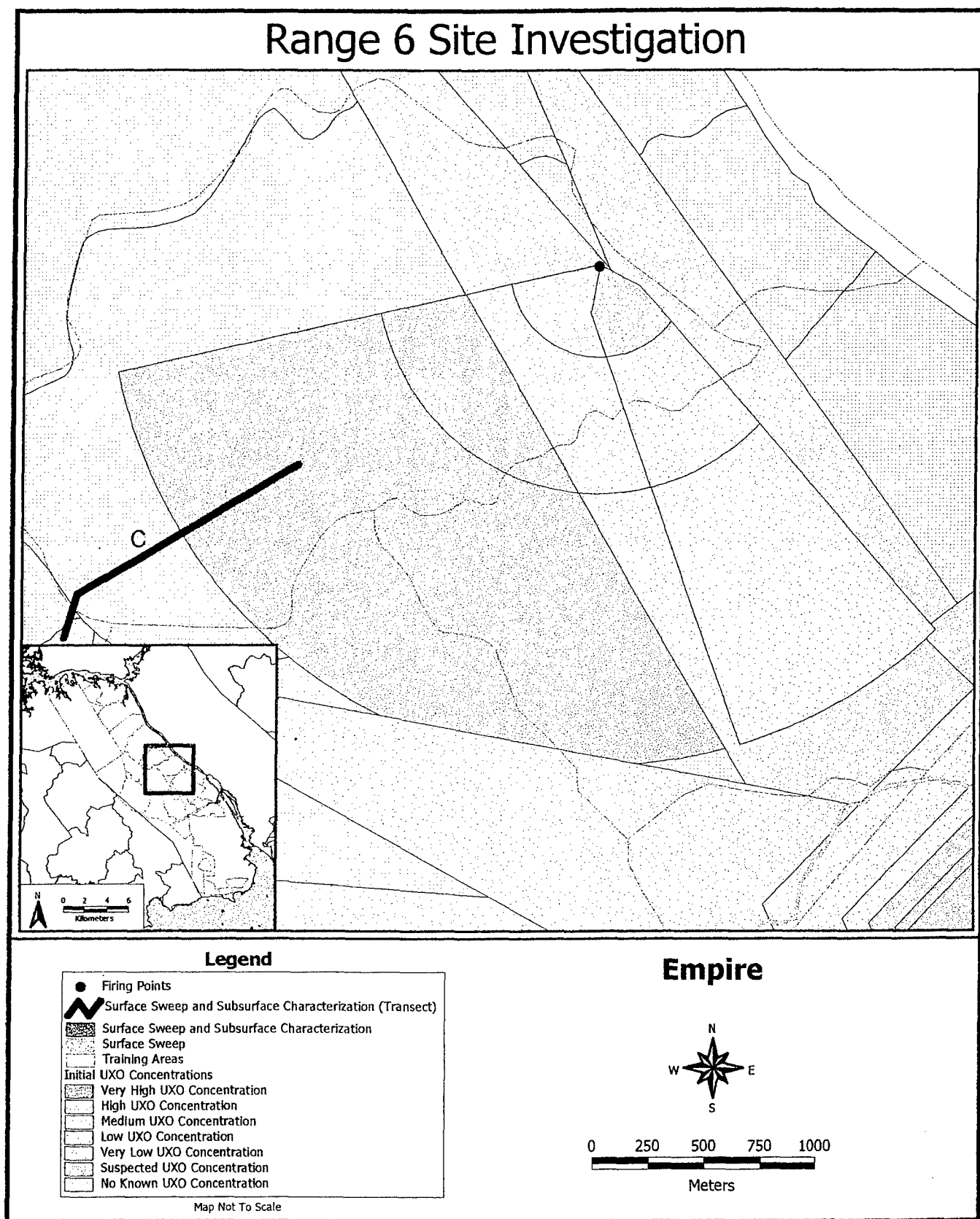
#### **SI Results**

Twenty-seven anomalies were detected and interrogated along the 929.9 meter, 19 segment transect. Of the 27 targets, (10) were magnetic rock, (7) were non-ordnance related, and (10) were frag or ordnance related scrap. Included in the (10) ordnance related targets were a 105mm base plate, 81mm mortar fuze, and a 3.5" Rocket mortar. The transect and target information for the transect survey are listed in Appendix D (transect segments C3-C21). Detailed target data for some of the targets removed are listed in Appendix C.

#### **SI Conclusions**

Although no UXO were found on the suspect area of Range 6 impact area enough of frag and ordnance related scrap was found to characterize the area as a low UXO concentration AOC.

## Range 6 Site Investigation



Map 8-8 Range 6 Site Investigation

### **8.3 Areas of Interest on The Empire Range**

In addition to the previously discussed UXO AOCs and suspected UXO AOCs, the UXO Assessment Report identified several areas of interest on the Empire Range. These areas differ from the previously discussed UXO AOCs and suspect UXO AOCs because either insufficient information is available to formulate conclusions regarding their UXO concentrations or they are unlikely to contain UXO. Areas of interest that were investigated on Empire during the SI include the following:

- Tire House Complex
- Training Area 42 Old Ammunition Depot
- Training Area 49 Observation Point 4

These areas of interest are discussed in the following sections.

#### **8.3.1 Tire House Complex**

Below are the background, SI activities, SI results and SI conclusions for the Tire House Complex.

##### **Background – Initial Characterization**

The Tire House Complex is a four-room structure made of tires that is used to train teams and individuals in the techniques of entering, clearing, and securing a building and its rooms. Ordnance used at the Tire House Complex is restricted to small-arms munitions, fragmentation hand grenades, and plastic explosives. Hand grenade use is limited to three rooms of the Tire House Complex.

##### **SI Activities**

SI activities included the subsurface sampling of three 50' x 50' grids and one 326 meter transect. The transect was conducted from the edge of the tire house area working into the buffer zone for that area.

##### **SI Results**

Only a small amount of anomalies were detected in the survey areas, which all proved to be non-ordnance related. After the targets were removed the areas were re-surveyed to ensure multiple targets did not exist there.

## **SI Conclusions**

During the SI no evidence was discovered which indicated the presence of surface or subsurface UXO concentrations. Therefore, the Tire House Area has been eliminated from the list of UXO areas of interest.

### **8.3.2 Training Area 42 Old Ammunition Depot**

Below are the background, SI activities, SI results and SI conclusions for the Training Area 42 Old Ammunition Depot.

#### **Background – Initial Characterization**

Training Area 42 Old Ammunition Depot ASP was not included in the initial UXO Assessment Report but is included in this report. Training area 42 was an ammunition depot that was used to store munitions, at one point and is currently used as a tear gas training facility where soldiers are exposed to low levels of tear gas for protective mask confidence training.

#### **SI Activities**

SI activities at this location included three sample grids that were surveyed with a Mk 26 ferrous ordnance locator.

#### **SI Results**

Ten lbs of non-ordnance related scrap materials were removed from the area. No significant ordnance related materials or UXO were discovered within the survey grids.

#### **SI Conclusions**

No evidence has been found which indicates the potential for UXO at this location.

## **8.4 Other Areas on The Empire Range**

### **8.4.1 Training Area 49 Observation Point 4 (OP-4)**

Observation Point 4 (OP-4) located in TA 49 was not included in the initial UXO Assessment Report but was visited during the SI effort. The OP was used to monitor the Empire Range during certain training activities.

#### **SI Activities**

SI activities at this location included one sample grid that was surveyed with a Mk 26 ferrous ordnance locator. The grid was located on top of the hill at grid coordinates PV4979097689.

#### **SI Results**

Six anomalies were detected and interrogated within the grid and all proved to be non-ordnance related including magnetic rocks. However, the area was re-visited shortly after a wildfire and one 105mm projectile UXO item was located and removed.

#### **SI Conclusions**

There is no valid reason why the UXO item was found at the Observation Point. The conclusion is that this was an isolated incident for that area. Records did not indicate ordnance usage in the area at any time. It has been eliminated from the UXO areas of interest because no other UXO information was found for that area.

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Piña and Balboa West Ranges*

## **9.0 SITE INVESTIGATION - BALBOA WEST RANGE**

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This section presents background initial characterization, SI activities, SI results and conclusions about each UXO AOC, and suspect UXO AOC on the Balboa West Range that were affected by the SI. The SI activities conducted at each of the TTs and Live Ordnance Area (LO-B) area were identical and are listed in Section 9.1. Areas listed in the UXO Assessment report that were not part of the SI activities are not listed in this report, unless information or data was discovered during the SI that has changed the characterization or conclusion for that area.

### **9.1 UXO Areas of Concern on The Balboa West Range**

The Balboa West Range UXO AOCs that were investigated during the SI include the following:

- Tactical Target 1 (TT-1)
- Tactical Target 2 (TT-2)
- Tactical Target 3 (TT-3)
- Tactical Target 4 (TT-4)
- Tactical Target 5 (TT-5)
- Tactical Target 6 (TT-6)
- Tactical Target 7 (TT-7)
- Tactical Target 8 (TT-8)
- Live Ordnance Area – B (LO-B)

These UXO AOCs are grouped together and discussed in the following sections.

#### **9.1.1 Tactical Targets 1 - 8 and LO-B Areas**

Below are the background, SI activities, SI results and SI conclusions for the Tactical Targets 1 - 8 and LO-B Areas.

## **Background - Initial Characterization**

The initial UXO concentration analysis of the TTs and LO Area was estimated by overlaying an hourglass-shaped ordnance dispersion pattern on each TT and LO Area. This pattern consisted of a 100-meter-radius target area, a 200-meter-radius safety buffer zone around each target area, and ordnance deployment error zones over the aircraft approach and departure paths. At the Balboa West Range, aircraft typically approach targets from the southeast and exit to the northwest; therefore, the UXO density pattern was aligned with this flight path to estimate the UXO concentrations. Impact areas, approach and departure paths, and safety buffer zones were assigned very-high, high, and medium UXO densities, respectively.

U.S. Army training activities were also conducted at the Balboa West Range. Impact areas used during these training exercises include TTs 3, 5, 6, 7, and 8 and LO Areas A and B. Table 9-1 lists the current ordnance used on the TTs and LO areas according to the last Balboa West Range operating procedure. According to Balboa West Range clearance records, ground-deployed UXO items have been collected from various TTs and LO Areas over the years. Table 9-2 lists other types of U.S. Army and U.S. Air Force and Army ordnance reportedly employed at the tactical target and live ordnance areas that are not listed in the range operating procedure.

**Table 9-1 Area Descriptions And Authorized Ordnance For The TTs (1-8) And LO-B**

TT or LO Area	Description	Authorized Explosive Ordnance
1	A small clearing simulating an enemy bivouac area	<ul style="list-style-type: none"> <li>•2.75-inch Folding Fin Aircraft Rocket (FFAR)</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
2	A small trail simulating a convoy on a jungle road	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> </ul>
3	A large clearing simulating a base camp with an assault runway	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
4	A small trail simulating a convoy on a jungle road	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
5	A large, kidney-shaped clearing with two bomb circles at the north and south ends	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
6	A small, rectangular clearing about 200 square meters in size with salvage vehicles for targets	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
7	A simulated bivouac area with vehicles	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
8	A small clearing simulating a resupply area	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•40mm grenades</li> </ul>
LO Area B	A clearing simulating an enemy command post with vehicles	<ul style="list-style-type: none"> <li>•2.75-inch FFAR</li> <li>•BDU-33/MK106</li> <li>•General purpose bombs (HE and inert filled)</li> <li>•20, 30, 40, and 105mm artillery projectiles</li> <li>•40mm grenades</li> </ul>

Source: U.S. Air Force 1992

**Table 9-2 Other Ordnance Types Reportedly Used At TTs (1-8) And LO Areas**

HE bomb M-117 (750 pounds)
Practice bombs (BDU-45)
Old Style Army-Navy series practice bombs (100 and 500 pounds)
Fire bombs (napalm) (various sizes and types)
Old Style Army-Navy series HE bombs (100, 250, 500, and 1,000 pounds)
Old Style Army-Navy series fragmentation bombs (90, 120, and 260 pounds)
60mm mortars
81mm mortars
66mm LAW rockets
83mm AT-4 rockets
Smoke grenades
Grenade and artillery simulators

## SI Activities

The SI activities conducted at TTs-1-8 and LO-B consisted of surface sweeping the accessible portions of each TT's. Each TT and LO-B area was cleared of tall grass and vegetation prior to the sweep in the accessible areas using the ARTS and slash and burn techniques. All surface UXO and ordnance related scrap was removed from the areas. In addition the access roads were surface cleared to distances up to 100 feet wide.

## SI Results

A total of hectares 62 hectares was surface cleared of UXO and related scrap. 378 UXOs and over 73,000 kgs of scrap were removed from the TTs 1-8 and LO-B areas. Table 9-3 lists the UXO and scrap removed from each of the eight tactical target areas and one live ordnance area surface cleared.

**Table 9-3 UXO And Scrap Removed From TTs (1-8) And LO-B**

		TT - 1	TT - 2	TT - 3	TT-4	TT-5	TT-6	TT-7	TT-8	LO-B
5.56 mm Blank	UXO			5						
	Scrap			2						
5.56 mm Ball	UXO			21						
	Scrap									
7.62 mm Blank	UXO			4						
	Scrap									
7.62 Ball	UXO			34						
	Scrap			1						
20 mm TP	UXO									
	Scrap			311	162	144				
20 mm HEI	UXO			73	29	30	35			180
	Scrap									
30 mm TP	UXO			2						
	Scrap			1	7	36				27
30 mm HE	UXO			2						
	Scrap									
40 mm TP	UXO				11	16	6			
	Scrap			47		51		1		
40 mm HE	UXO			1						
	Scrap									
MK 13	UXO			2	2					
	Scrap			11						
MK 18	UXO			5	5					
	Scrap	1		28					1	
BDU-33	UXO		2	161	42	160	35			13
	Scrap			6		5				
BDU-50	UXO				1					
	Scrap			8		50	2			3
Flares	UXO			3						
	Scrap			17						
M14 WP Grenade	UXO			2						
	Scrap			2						
2.75" RKT	UXO			1						
	Scrap			2				1		
Asstd Fuzes	UXO			5						4
	Scrap									
MK 124 Signals	UXO			30						
	Scrap									
AT - 4	UXO				1					
	Scrap									
M35 3.5" Bazooka	UXO									
	Scrap									2
<b>TOTALS</b>		<b>1</b>	<b>2</b>	<b>787</b>	<b>260</b>	<b>492</b>	<b>78</b>	<b>2</b>	<b>1</b>	<b>229</b>

## **SI Conclusions**

The accessible areas of TTs-1-8 and LO-B (see Map 9-1), were surface cleared of UXO and ordnance related scrap. The total area surface cleared in the TTs 1-8, and LO-B areas and access roads amounted to approximately 62 hectares. The entire Balboa West Range has been closed for ordnance training and/or testing since January 1998; therefore the UXO concentration levels have not increased since the finalization of this report. No subsurface surveys, characterizations, or UXO removal operations were conducted at these areas, but based upon the large amounts of UXO removed from the surface during the SI and over the years indicates a very strong potential for large amounts of subsurface UXO. Therefore, the TT and LO areas remain classified as high to very-high with respect to UXO concentrations.

### **9.2 Suspect UXO Areas of Concern on The Balboa West Range**

This section describes areas that are suspected to contain some amount of UXO. These areas were not designated as UXO AOCs because no direct evidence was found indicating that they contain UXO; instead, indirect evidence or anecdotal information suggests that UXO may be present. In each case, insufficient information was found to reasonably estimate the UXO density and hazard level.

Suspect UXO AOCs that were investigated on Balboa West during the SI include the following:

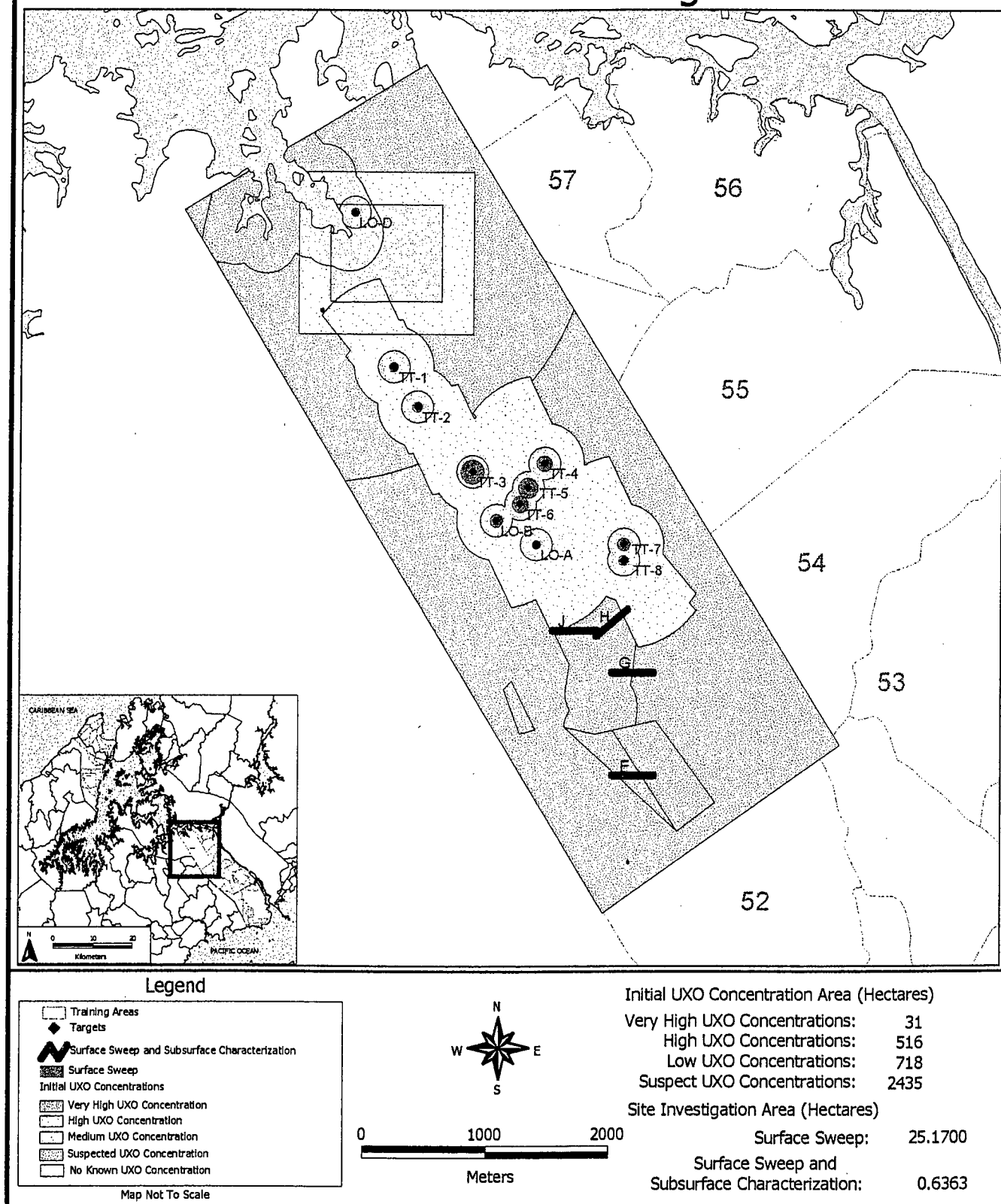
- Suspect Army-Navy Bombing Area
- Suspect Army Ground Ordnance Area
- Suspect Area Outside TT-8 Bombing Pattern
- Suspect Area Outside LO-A Bombing Pattern

These suspect UXO AOCs are discussed in the following sections.

#### **9.2.1 Suspect Army-Navy Bombing Area**

Below are the background, SI activities, SI results and SI conclusions for the Suspect Army-Navy Bomb Area.

# Balboa West Site Investigations



## **Background - Initial Characterization**

An Army-Navy series bomb area was identified in the south portion of the Balboa West Range. The area is estimated to be about 600 by 1,200 meters in size where reportedly, Army-Navy series bombs have been found. The Army-Navy bomb series was used between the World War II and Vietnam War eras. The number of ordnance items in this area and the area's years of operation are unknown.

## **SI Activities**

The SI activities conducted at the suspect Army-Navy series bombing area consisted of a subsurface transect survey 1004 meters in length. The transect was started from the K-16 road using a hand held EM61 electromagnetic locator working into the suspect area. The transect is shown on Map 9-1. The segment data for transect F can be found in Appendix D.

## **SI Results**

Of the 17 segments surveyed on the 1004 meter long transect only four anomalies were located. Three of the four anomalies were attributed to small arms links, casings or blanks. Appendix D lists the targets and segment data for transect F surveyed on the suspect Army-Navy series bombing area. The target areas were re-surveyed after target removal to ensure that multiple targets did not exist.

## **SI Conclusions**

Only a small amount of anomalies were located (4), and all were determined to not hazardous. In addition there were no signs of surface UXO or ordnance related materials. This area, therefore, has been eliminated as a suspect UXO AOC.

### **9.2.2 Suspect Army Ground Ordnance Area**

Below are the background, SI activities, SI results and SI conclusions for the Suspect Army Ground Ordnance Area.

## **Background - Initial Characterization**

The U.S. Army conducted various unknown training activities at the Balboa West Range. Ground-deployed ordnance has been reported in the area of Road K-16. Also, TTs 7 and 8 and LO Area A were

authorized for use in training activities by the U.S. Army. Therefore, an area that extends about 400 meters from each side of Road K-16 and TTs 7 and 8 is suspected to contain UXO.

### **SI Activities**

The SI activities conducted at the Suspect Army Ground Ordnance Area consisted of a subsurface transect survey 520 meters in length. The transect was started from the K-16 road using a hand held EM61 locator working into the suspect area. The transect is shown on Map 9-1. The segment data for transect G can be found in Appendix D.

### **SI Results**

Of the 10 segments surveyed on the 520 meter long transect only (i) anomaly was located. The one anomaly was interrogated and turned out to be a beer can at a depth of < .5 meters. Appendix D lists the target and segment data for transect G, conducted on the Suspect Army Ground Ordnance Area. The target area was re-surveyed after the removal of the beer can to ensure that multiple targets did not exist.

### **SI Conclusions**

Only one anomaly was located and was attributed to a non-related ordnance item. In addition there were no signs of surface UXO or ordnance related materials. This area therefore, has been eliminated as a suspect UXO AOC.

### **9.2.3 Suspect Area Outside TT-8 Area**

Below are the background, SI activities, SI results and SI conclusions for the Suspect Area Outside TT-8 Area.

#### **Background - Initial Characterization**

The areas outside the TT and LO Area dispersion patterns are suspected of containing UXO. The ordnance items suspected to be present include mortar projectiles, recoilless rifle projectiles, and projected grenades.

## **SI Activities**

The SI activities conducted at the suspect area outside TT-8 consisted of a subsurface transect survey 515 meters in length. The transect was surveyed with a hand held EM61. The transect is shown on Map 9-1. Segment data for transect H can be found in Appendix D.

## **SI Results**

Of the 7 segments surveyed on the 520 meter long transect (7) anomalies were located. One target was due to 20 mm links, four targets were un-relocatable and two were pieces of frag. The (4) targets un-relocatable are considered negligible because the original response and magnitude of each signal, compared to the 20 mm link, indicates that all four targets are estimated to be much smaller than casings from a small arms round. Two pieces of frag were located about midway through the transect at a depth of <1 meter. Appendix C provides details for most of targets interrogated during the transect. The intrusive area was re-surveyed after target removal to ensure that multiple targets did not exist.

## **SI Conclusions**

The two pieces of frag located midway through the target, although harmless themselves, are of interest because they are ordnance related. The smallest piece of frag was analyzed with the fragmentation analysis software (TM 855-1), and the estimated travel range was determined to be 256 meters. By plotting a 256 meter radius on the transect overlay at the target location, it was deemed possible that the fragmentation could have been attributed to a detonation within the bombing pattern of TT-8 as defined in the UXO assessment report. Therefore, without any other evidence indicating surface or subsurface UXO concentrations, this area has been eliminated as a suspect UXO AOC. The larger piece of frag was not analyzed because it would have had a greater travel distance than the smaller.

### **9.2.4 Suspect Area Outside LO-A Area**

Below are the background, SI activities, SI results and SI conclusions for the Suspect Area Outside LO-A Area.

#### **Background - Initial Characterization**

The areas outside LO-A Area dispersion patterns are suspected of containing UXO. The ordnance items suspected to be present include mortar projectiles, recoilless rifle projectiles, and projected grenades.

## **SI Activities**

The SI activities conducted at the suspect area outside LO-A consisted of a subsurface transect survey 563 meters in length. The transect was surveyed with a hand held EM61 electromagnetic locator. The transect is shown on Map 9-1. The segment data for transect J can be found in Appendix D.

## **SI Results**

Of the 9 segments surveyed on the 563 meter long transect, (4) anomalies were located. One target was a 20 mm cartridge, one was an ammunition (non-hazardous) clip, one was a magnetic rock and one target was part of a fin from a 2.75 inch folding fin rocket. Appendix C provides details for most of targets interrogated during the transect. The intrusive area was re-surveyed after target removal to ensure that multiple targets did not exist.

## **SI Conclusions**

The only target of concern in the transect was the rocket fin which, although harmless itself, indicates that detonations may have taken place in close proximity to that location. Since the target location was very close to the end of the transect and actually into the pattern for LO-A as defined in the assessment report, it is assumed that the frag came from impacts within the bombing pattern of LO-A. Therefore, because of the lack of significant ordnance related targets within the area and no signs of surface ordnance related debris along the transect, the area has been eliminated as a suspect UXO AOC.

*UXO Site Investigation For  
U.S. Military Ranges in Panama:  
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## **10.0 SITE INVESTIGATION - PIÑA RANGE**

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This section presents background initial characterization, SI activities, SI results and conclusions about each UXO AOC, and suspect UXO AOC on the Piña Range that were affected by the SI. Areas listed in the UXO Assessment report that were not part of the SI are not listed in this section unless information or data was discovered during the SI that changed the conclusions for the area.

### **10.1 UXO Areas of Concern on The Piña Range**

The Piña Range UXO AOCs that were investigated during the SI include the following:

- Piña Multipurpose Range
- Piña Live Fire Village and Access Road

These UXO AOCs are discussed in the following sections.

#### **10.1.1 Piña Multipurpose Range**

Below are the background, SI activities, SI results and SI conclusions for the Piña Multipurpose Range.

##### **Background - Initial Characterization**

The Piña Multipurpose Range currently operates as a small-arms range and is located in a relatively level river valley along the west side of Road S10. The range is characterized by a firing fan directed toward the Piña Impact Area. The firing fan extends from the Piña Multipurpose Range FP to the approximate midpoint of the Piña Impact Area. Because it is a multipurpose range, the activities involved a wide variety of ordnance types, including projected grenades, rockets, and mortar, Howitzer and recoilless rifle projectiles. The Piña Multipurpose Range firing fan has been classified with high, medium, and low UXO densities. The high UXO density area is defined by the maximum range of 40mm projected grenades, and it may also contain short-fired mortar and recoilless rifle projectiles, guided missiles, and rockets. The medium UXO density area outside the Piña Impact Area may contain unexploded mortar and recoilless rifle projectiles, guided missiles, and rockets. The medium UXO density area inside the Piña Impact Area may contain unexploded mortar projectiles and guided missiles. The low UXO density area may contain unexploded mortar and recoilless rifle projectiles and guided missiles.

## **SI Activities**

SI activities consisted of ordnance clearance activities in the accessible areas of the Piña Multipurpose Range. Task Force 111 EOD personnel made an initial sweep of the surface to locate and identify UXO in the area. The area was then bulldozed to move the topsoil to the sides of the range. A second visual sweep of the range was conducted removing UXO and scrap from the accessible areas of the Multipurpose range. Map 10-1 illustrates the areas where SI activities were conducted.

## **SI Results**

As a result of the SI activities, (31) UXO items were located and cleared from the Piña Multipurpose Range. The UXO items removed from the area are included in Table 10-1.

**Table 10-1 Ordnance Removed From The Piña Multipurpose Range**

<b>UXO TYPE</b>	<b>QUANTITY</b>
40 mm HEDP	15
40 mm Illum	9
Rocket LAW Warhead	2
Rocket TEA	1
Simulator M115A2	1
Rocket 35mm Sub-Cal LAW	3

Ordnance Related Scrap 750 lbs

Non-Ordnance Related Scrap 18,150 lbs

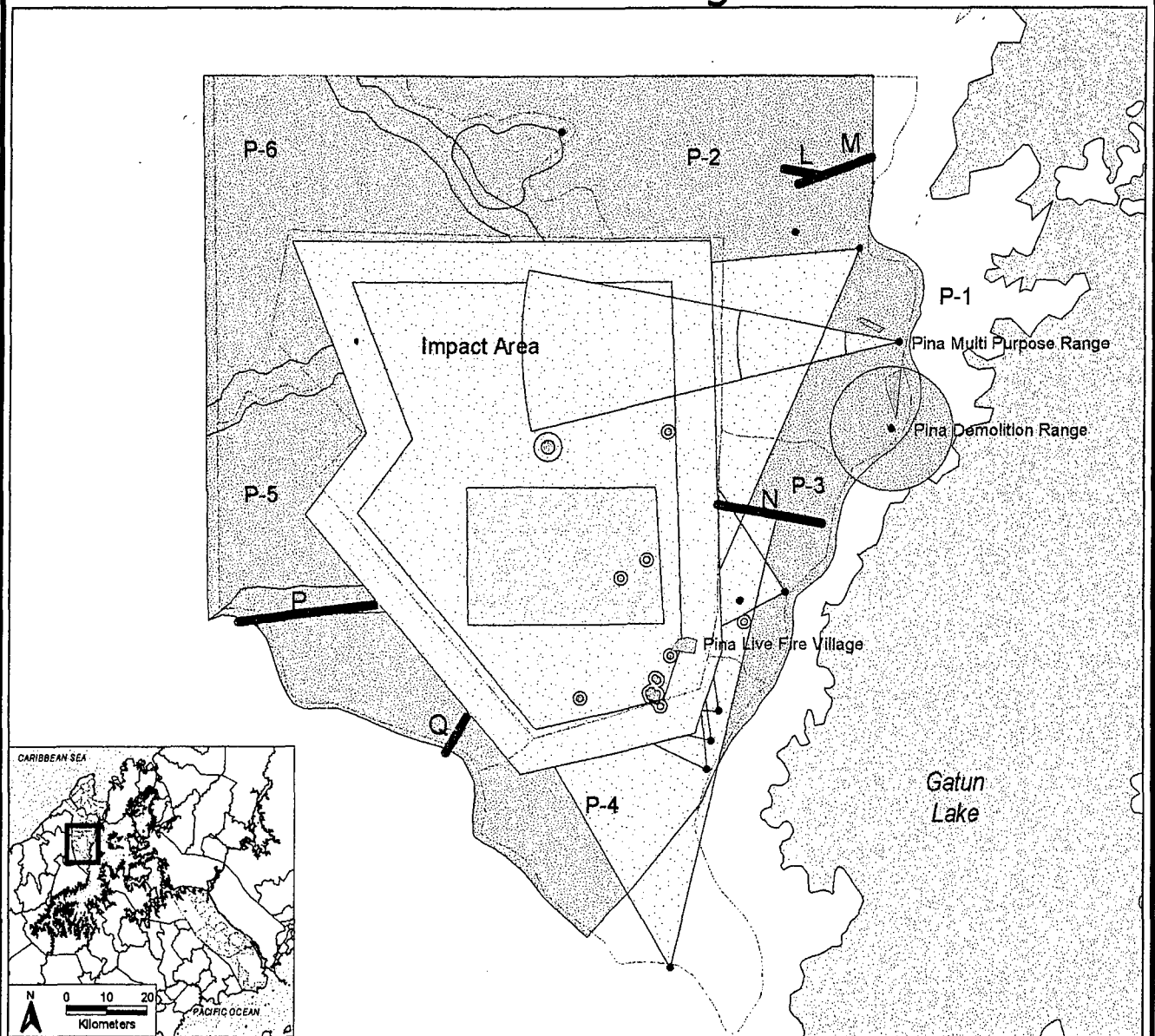
## **SI Conclusions**

The accessible areas of the Piña Multipurpose Range were cleared of UXO, OE scrap and non-OE scrap from the surface and the first few inches of topsoil. However, the range has been used since the SI and continues to remain open, so the potential for additional surface and subsurface UXOs exists so it remains classified as a UXO AOC.

### **10.1.2 Piña Live Fire Village and Access Road Areas**

Below are the background, SI activities, SI results and SI conclusions for the Piña Live Fire Village and Access Road Areas.

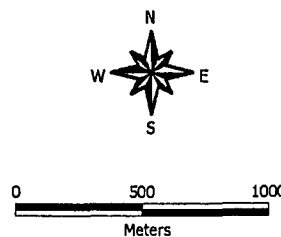
# Piña Site Investigations



## Legend

- Firing Points
- Surface Sweep and Subsurface Characterization
- Surface Sweep
- Training Areas
- Initial UXO Concentrations**
  - Very High UXO Concentration
  - High UXO Concentration
  - Medium UXO Concentration
  - Low UXO Concentration
  - Very Low UXO Concentration
  - Suspected UXO Concentration
  - No Known UXO Concentration

Map Not To Scale



## Initial UXO Concentration Area (Hectares)

Very High UXO Concentrations:	3.4
High UXO Concentrations:	154.0
Medium UXO Concentrations:	502.0
Low UXO Concentrations:	362.0
Very Low UXO Concentrations:	233.0
Suspect UXO Concentrations:	1265.0

## Site Investigation Area (Hectares)

Surface Sweep Only:	4.49
Surface Sweep and Subsurface Characterization:	0.89

Map 10-1 Piña Site Investigations

## Background - Initial Characterization

The Piña Live Fire Village was not included in the initial UXO assessment report, however background material is presented here. Piña Live Fire Village, also called the Live Fire Raid Module, is a small village complex consisting of one-two and two one-story buildings at the southeastern edge of the Piña Impact area. The terrain is generally flat and covered by grass and patches of hard clay. Vietnam grass (*Saccharum spontaneum*) covers approximately 30% of the total area.

## SI Activities

SI activities consisted of ordnance clearance activities in the accessible areas of the Piña Live Fire Village. Task Force 111 EOD personnel burned and removed the surface vegetation from the area and then conducted a visual surface sweep of the accessible area. UXO and range scrap were removed from the accessible areas of the Live Fire Village area. A portion of the access road leading into the Live Fire Village Area was also surface cleared. Map 10-1 shows the areas where SI activities were conducted.

## SI Results

As a result of the SI activities, (38) UXO items were located and cleared from the Piña Live Fire Village Area. The UXO items removed from the area are included in Table 10-2.

**Table 10-2 Ordnance Removed From The Piña Live Fire Village**

UXO TYPE	QUANTITY
40 mm Training	20
Grenade Simulator	1
Rocket 3.5" WP	1
Mortar 60mm HE	3
Mortar 60mm WP	1
Slap Flare	2
5.56 mm Small Arms	10

Ordnance Related Scrap 200 lbs

Non-Ordnance Related Scrap 1,500 lbs

## **SI Conclusions**

The accessible areas of the Live Fire Village were surface cleared of UXO, OE scrap and non-OE scrap. The level of surface UXO found in the area and the lack of subsurface activities is an indicator that subsurface UXO exists at the Piña Live Fire Village area so it remains classified as a low to medium UXO concentration area.

### **10.2 Suspect UXO Areas of Concern on The Piña Range**

This section describes areas that are suspected to contain UXO. These areas were not designated as UXO AOCs because no direct evidence was found indicating that they contain UXO; instead, indirect evidence or anecdotal information suggests that UXO may be present. In each case, insufficient information was found to reasonably estimate the UXO density and hazard level.

Suspect UXO AOCs that were investigated on the Piña Range during the SI include the following:

- Piña Demolition Range
- Piña 1960's Impact Area

These suspect UXO AOCs are discussed in the following sections.

#### **10.2.1 Piña Demolition Range Area**

Below are the background, SI activities, SI results and SI conclusions for the Piña Demolition Range Area.

##### **Background - Initial Characterization**

The Piña Demolition Range is a circular area with a diameter of 1,000 meters and is located in training area P-2 along the east edge of the Piña Range near Road S10. Materials used at the Piña Demolition Range included demolition charges, antitank and APERS land mines, and accessories employed to ensure their demolition. This area is used to conduct blasting, demolition, hand grenade, and mine training activities. UXO is suspected to be present within the Piña Demolition Range.

## **SI Activities**

SI activities consisted of UXO clearance activities in the accessible areas of the Piña Demolition Range. Task Force 111 EOD personnel burned and removed the surface vegetation from the area and then conducted a visual surface sweep of the accessible area of the Demolition Range Area for UXO and range scrap. Map 10-1 shows the areas where SI activities were conducted.

## **SI Results**

No significant UXO or scrap material was discovered on the accessible areas of the Piña Demolition Range.

## **SI Conclusions**

The accessible areas of the Piña Demolition Range were surface swept for UXO and scrap. No UXO or significant items of interest were recovered or are currently known to exist there, so the Piña Demolition area was eliminated from as a suspect UXO AOC, however the range has been in use since the SI and continues to remain open, so a potential exists for additional UXO. The extent to which the area has been used since the SI is unknown.

### **10.2.2 Piña 1960's Suspect Impact Area**

Below are the background, SI activities, SI results and SI conclusions for the Piña 1960's suspect Impact Area.

#### **Background - Initial Characterization**

According to the UXO Assessment report the Piña Impact Area occupied almost the entire Piña range during the 1960's time era. Sometime between the late 1960's and 1980, the Piña Impact Area boundaries were established in their current configuration. Because the impact area has appeared to have been reduced in size, between 1960 and 1980, the area effected by the reduction is suspected of containing UXO.

#### **SI Activities**

Five subsurface transects were conducted in the area that was included in the suspect 1960's impact area, but outside of the current impact area. Two transects were conducted in the northeastern portion

(transects L 578 meters & M 275 meters). One transect was conducted in the eastern portion overlapping parts of the firing fans for the Piña Range (transect N 712 meters). One was conducted in the western area near the P-4 / P-5 training area boundary (transect P 946 meters). One transect was conducted in the southwestern portion of the area near the Rio Providencia potential washout area as defined in the UXO assessment report (transect Q 308 meters). Each of the five transects were surveyed with a hand held EM61 detector. The transects were chosen based on the UXO assessment report and the accessibility of the site. The segment data for transects L, M, N, P, and Q can be found in Appendix D.

## **SI Results**

In the northeastern portion there were two transects, L & M. On the 578 meter long L transect, there was only one target which turned out to be non-ordnance related. On the 275 meter long M transect, there was only one target, a M16 magazine which was non-hazardous.

In the eastern portion of the area, overlapping parts of the firing fans for the Piña Range, one transect was surveyed. On the 712 meter long N transect, four targets were located. Two were non-ordnance related and one was a non-hazardous cartridge from a 40mm round. The fourth target was un-relocatable but the detector response indicates that the item was smaller than a small arm.

In the western area near the Rio Providencia potential washout, one transect was surveyed. On the 946 meter long P transect, (12) targets were located. Ten of the targets were ordnance fragmentation pieces including a base plate. One target was a battery and the other was un-relocatable.

In the southwestern portion of the area near the P-4 / P-5 training area boundary, one transect was surveyed. On the 308 meter long transect (4) targets were located and were all non-ordnance related items (nails).

## **SI Conclusions**

Although the entire area between the current 1990's impact area boundary and the 1960's impact area boundary was initially classified as suspect in the UXO assessment report, the actual UXO concentrations vary within the sectors of the suspect area. Because of the positions of the firing points and types of weapons fired at Piña Range, the following conclusions were made. Ordnance were usually fired at targets that were in towards the center portion of the Piña Impact area. Ordnance related items were found in the two transects conducted in the northeastern sector therefore, the northern sector of the

1960's Piña Impact area has been eliminated as a suspect UXO AOC. The eastern section of the 1960's impact area contain several range fans for firing points. Although the possibility of UXO does exist due to short rounds the potential is very minimal due to the close proximity to the firing points. UXO in the immediate vicinity of the firing points would have been cleared to protect personnel and equipment occupying the firing points. Only one ordnance related item was discovered on the eastern transect (N), but the 40 mm practice cartridge was non-hazardous and has a short travel distance compared to some of the larger items. Because of the close proximity to the firing points and because that no known UXO exist in the sector, the eastern portion of the 1960's Impact Area it has been eliminated as a suspect UXO AOC. No evidence exists that ordnance were fired or that UXO exists in the southwestern sector of the 1960's Piña impact area. The western sector however, is considered to contain UXO due to the direction of fire from the firing points and the range of some of the weapons. The transect conducted within this sector indicated many ordnance related targets. Although, no UXO were found, the ordnance related targets recovered in the western area indicate the area was probably part of an impact area. Therefore, the western sector of the 1960's Piña Impact area has been characterized as having a medium UXO density level.

## 11.0 REVISED UXO CONCENTRATIONS

The UXO SI consisted of surface clearance efforts, subsurface characterization, and sampling efforts on certain areas of the Empire, Balboa West and Piña Ranges which are covered in section 8, 9, and 10 respectively. The overall purpose of the SI was to refine and/or confirm the results of the initial UXO assessment study that was based upon the historical and archival range records. As a result the UXO concentrations have been updated for Empire, Balboa West and Piña. A summary of SI activities and range land classifications are presented in Sections 11.1, 11.2, and 11.3 for the Empire, Balboa West, and Piña Ranges respectively.

### 11.1 Revised UXO Concentrations For The Empire Range

A summary of the SI activities conducted on the Empire Range is provided in Table 11.1.

**Table 11-1 Summary Of SI Activities On The Empire Range**

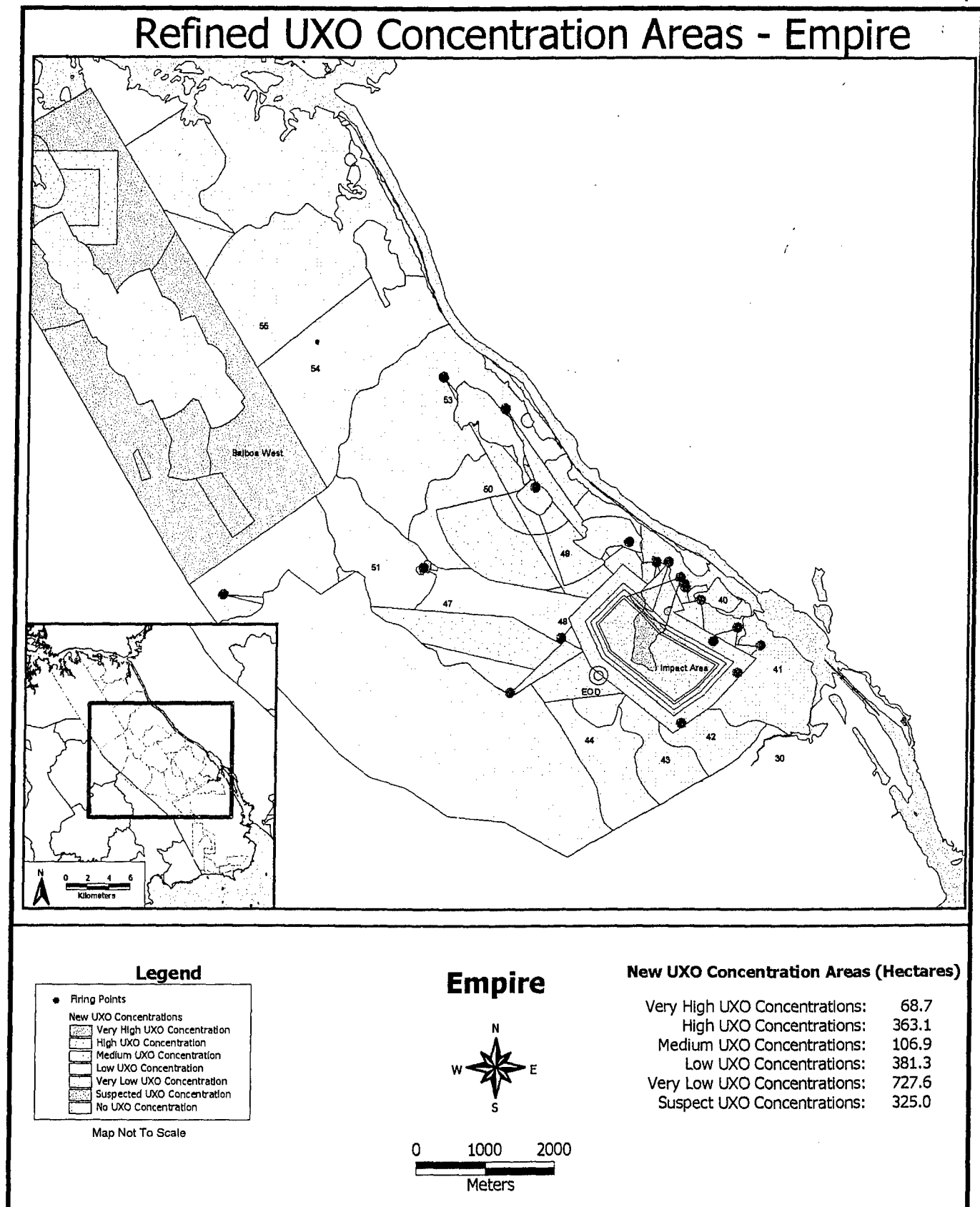
SI ACTIVITY	UNITS
Areas Surface Swept For UXO	61.67 Hectares
Areas Surface Swept and Subsurface Characterized	1.36 Hectares
UXO Removed From Empire	987 items
OE Scrap Removed From Empire	Over 10,900 Kgs
Non-OE Scrap Removed From Empire	Over 47,000 Kgs

As a result of the SI activities and ground truth data the Empire range has been re-assessed with respect to UXO concentration levels. The revised areas are shown on Map 11-1. The updated UXO concentration level breakdown is provided below in Table 11-2.

**Table 11-2 Summary Of Empire Range Land With Respect To UXO Concentration Levels**

Range	Hectares with Indicated UXO Density							Total Range Area
	Very-High	High	Medium	Low	Very-Low	Suspected	No Evidence of UXO	
Empire	68.7	363.1	106.9	700.7	727.6	325.0	4547	8873

1 hectare = 2.47 acres



Map 11-1 Refined UXO Concentration Areas - Empire

Refinements that have been made to the Empire UXO concentration map because of the SI activities and results covered in Section 8 including removing certain areas while changing the status of others. The following areas have been removed from the UXO concentration map: Firing Fan For Range 19, Firing Fan for FP-11, Firing Fan for FP-15, Rio Fuentes washout area, Rio Grande washout area, the suspect area associated with the EOD Range, and portions of Range 6. The following areas have been refined in terms of potential UXO concentration levels: Camp Bayonet Area has been upgraded from a medium UXO density to a high UXO density based on the types and amounts of ordnance believed to be there. The suspect Range 6 Impact Area has been assessed from a suspect area to a low UXO concentration area.

## 11.2 Revised UXO Concentrations For The Balboa West Range

A summary of the SI activities conducted on the Balboa West Range is provided in Table 11-3.

**Table 11-3 Summary Of SI Activities On The Balboa West Range**

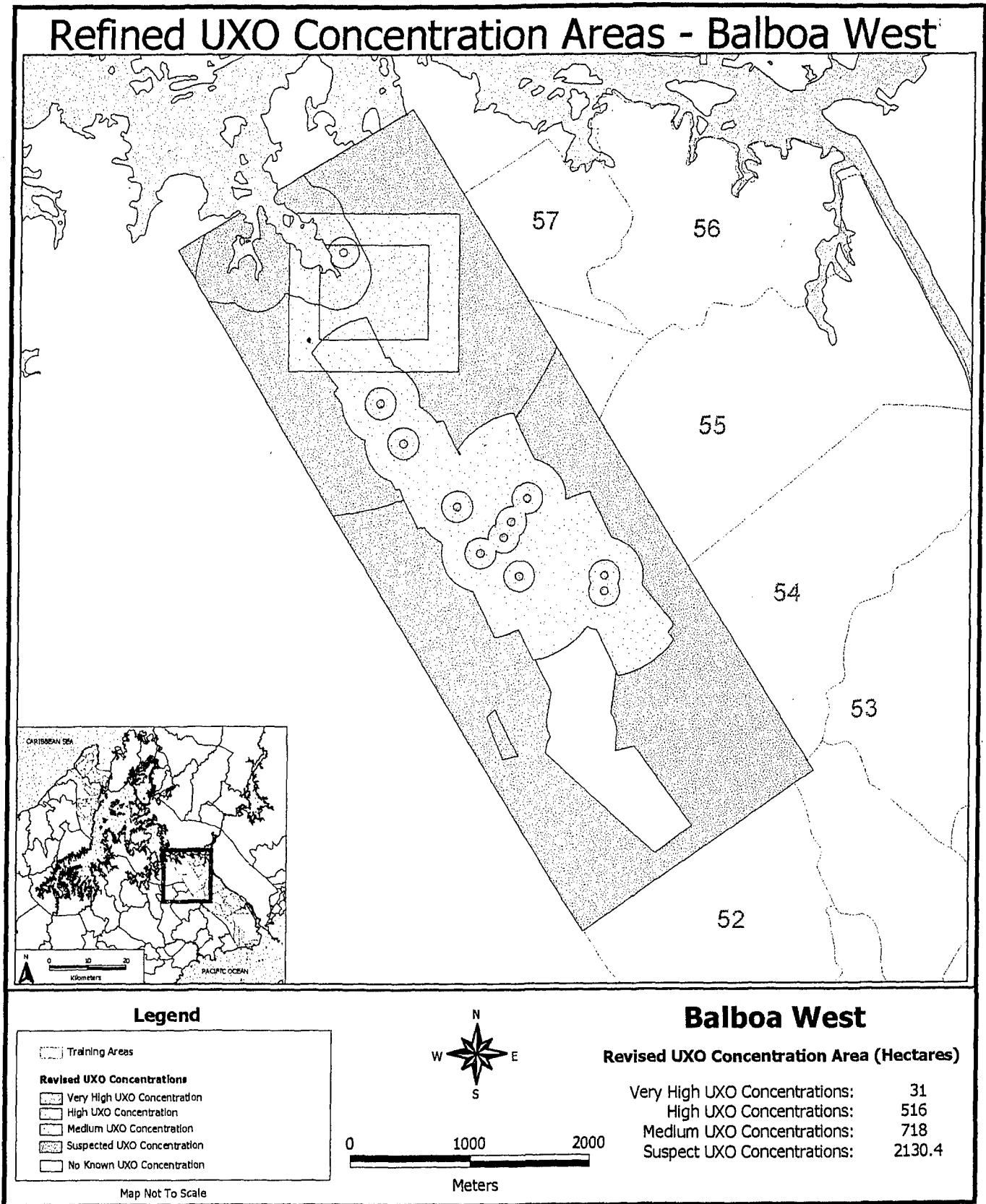
SI ACTIVITY	UNITS
Areas Surface Swept For UXO	25.17 Hectares
Areas Surface Swept and Subsurface Characterized	.6363 Hectares
UXO Removed From Balboa West	378 items
Scrap Removed From Balboa West	Over 73,000 Kgs

As a result of the SI activities and ground truth data the Balboa West Range has been re-assessed with respect to UXO concentration levels. The revised areas are shown on Map 11-2. The updated UXO concentration level breakdown is provided below in Table 11-4.

**Table 11-4 Summary Of Balboa West Range Land With Respect To UXO Concentration Levels**

Range	Hectares with Indicated UXO Density							Total Range Area
	Very-High	High	Medium	Low	Very-Low	Suspected	No Evidence of UXO	
Balboa West	31	516	718	NONE	NONE	2130.4	304.6	3,700

1 hectare = 2.47 acres



Map 11-2 Refined UXO Concentration Areas – Balboa West

Refinements that have been made to the Balboa West UXO concentration map include the removal of certain areas because of the SI activities and results covered in Section 9 of this report. The following areas have been removed from the UXO concentration map: the suspect Army-Navy Bombing Area, the suspect army ground ordnance area, the suspect area outside TT-8, and the suspect area outside LO-A.

### 11.3 Revised UXO Concentrations For The Piña Range

A summary of the SI activities conducted on the Piña Empire Range is provided in Table 11.5.

**Table 11-5 Summary Of SI Activities On The Piña Range**

SI ACTIVITY	UNITS
Areas Surface Swept For UXO	4.49 Hectares
Areas Surface Swept and Subsurface Characterized	.89 Hectares
UXO items Removed From Piña	69 items
OE Scrap Removed From Piña	Over 430 Kgs
Non-OE Scrap Removed From Piña	Over 8,900 Kgs

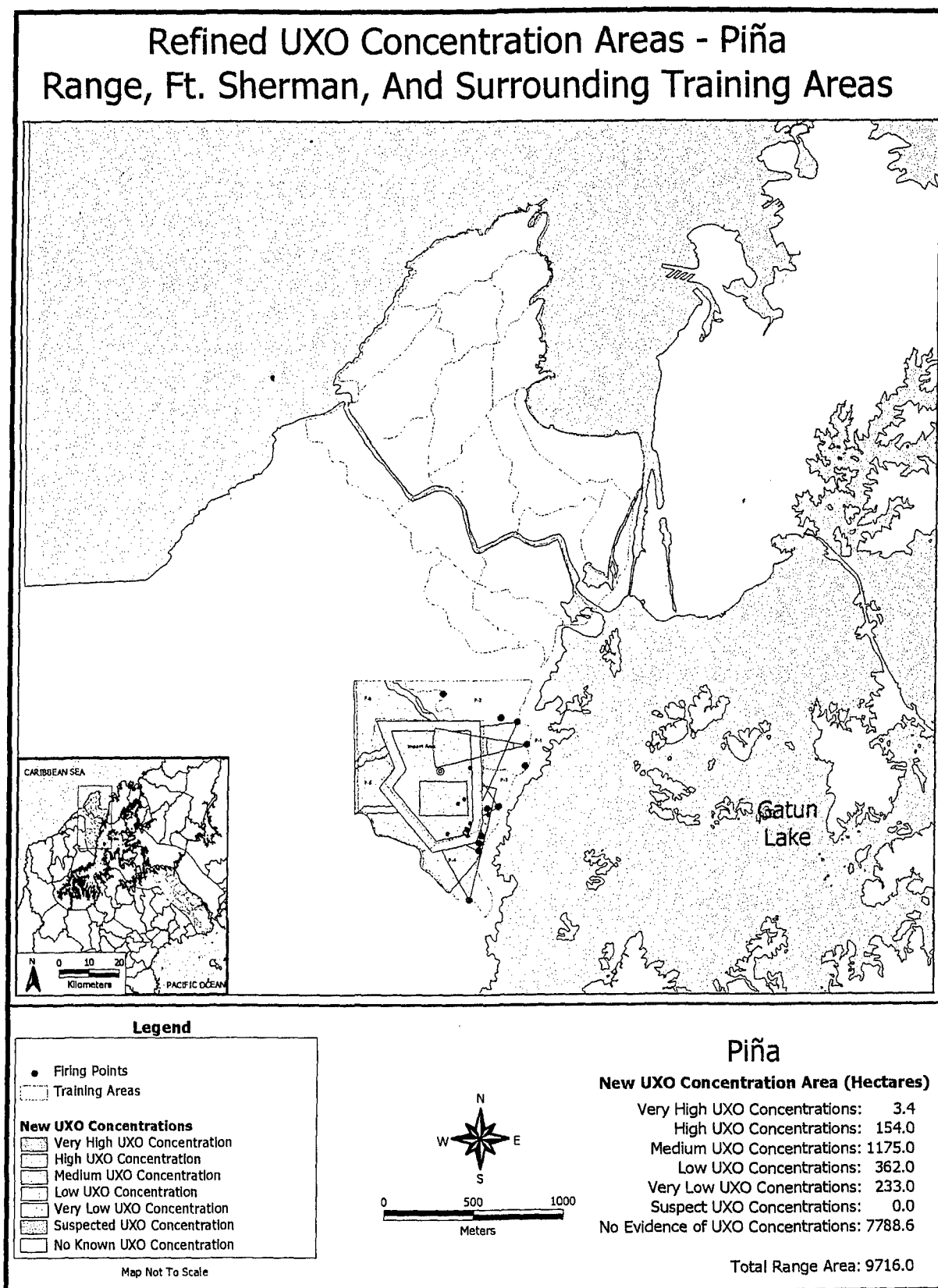
As a result of the SI activities and ground truth data collected and evaluated the Piña Range has been re-assessed with respect to UXO concentration levels. The updated UXO concentration level breakdown is provided below in Table 11-6. Map 11-3 shows the entire DoD controlled area for the Atlantic side including the Piña Range, FT Sherman, and surrounding maneuver and training areas. Map 11-4 is a close up view of the Piña Range.

**Table 11-6 Summary Of Piña Range Land With Respect To UXO Concentration Levels**

Range	Hectares with Indicated UXO Density							Total Range Area
	Very-High	High	Medium	Low	Very-Low	Suspected	No Evidence of UXO	
Piña	3.4	154.0	1175.0	362.0	233.0	0.0	7,788.6	*9,716

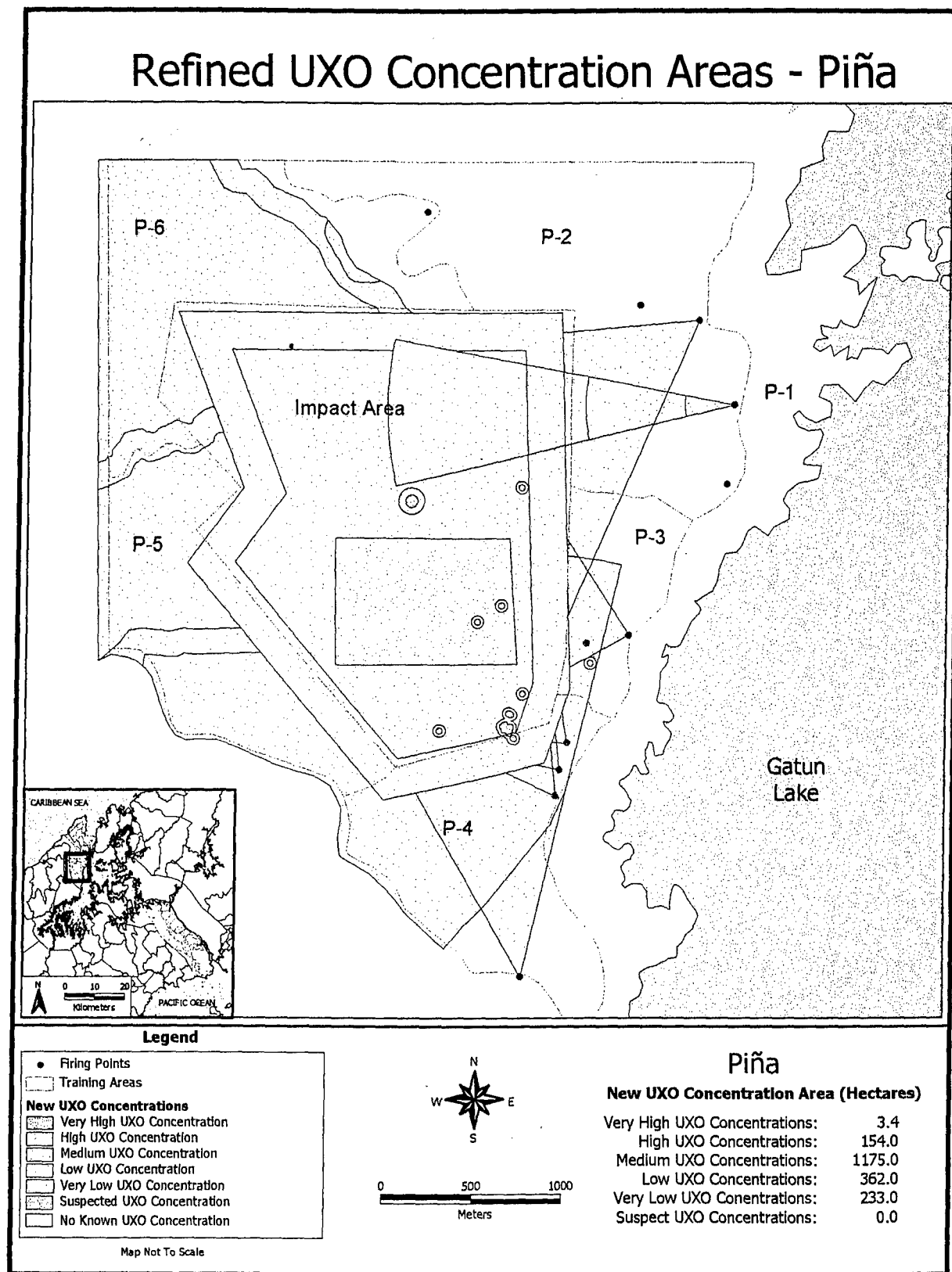
\* Includes FT. Sherman and surrounding Training and Maneuver Areas

1 hectare = 2.47 acres



Map 11-3 Refined UXO Concentration Piña Range, Ft. Sherman, And Surrounding Training Areas

Because of the results of the SI activities conducted on Piña which, are covered in Section 10 of this report, the Suspect 1960's Impact Area has been refined. The northeastern, and eastern portions have been eliminated from the UXO concentration map. The northwestern and western portions have been categorized as a medium UXO concentration.



Map 11-4 Refined UXO Concentration Areas - Piña

## **12.0 SITE INVESTIGATION CONCLUSIONS**

The SI provides ground truth data on UXO concentrations throughout various portions of the Empire, Balboa West and Piña Ranges. Areas investigated on the Empire Ranges included the Main Impact Area, Range 6, Range 1/1A, EOD Range, Camp Bayonet, Range 18, Rio Fuentes washout area, Rio Grande washout area, Range 6 suspect Impact Area, TA 42 Ammunition Depot, TA 49 OP-4, Tire House Complex, and the Firing Fan areas of FP-15, 11 and Range 19. Areas investigated on the Balboa West Range included TT 1-8, LO-B, Suspect Army-Navy Bombing Area, Suspect Army Ground Ordnance Area, and the Suspect Areas outside TT-8 and LO-A. Areas investigated on the Piña Range included the Multipurpose Range, Live Fire Village, Demolition Range, and the 1960's, suspect Impact Area.

SI activities included surface sweeping and subsurface characterizations using UXO detection technologies. A total of 91.33 hectares were surface swept for UXO and related debris, while 2.88 hectares were surface swept and subsurface characterized. During those activities 1,434 UXO, 11,330 Kgs of OE scrap, and 63,200 of non-OE range scarp were removed from the Ranges. This report discusses in detail the SI activities conducted, results and conclusions for each area investigated. The background assessment or initial characterization data is also presented for each area investigated. As a result of the data collected the initial UXO concentration assessment was refined and/or confirmed. Certain areas were eliminated from the UXO concentration maps while others were elevated with respect to the UXO concentration levels. The refined range area breakdown is presented in Table 12-1.

**Table 12-1 Hectares With Indicated UXO Density**

<b>Range</b>	<b>Hectares with Indicated UXO Density</b>							<b>Total Range Area</b>
	<b>No Evidence</b>	<b>Very-High</b>	<b>High</b>	<b>Med</b>	<b>Low</b>	<b>Very-Low</b>	<b>Suspected</b>	
Empire	4,547	68.7	363.1	106.9	700.7	727.6	0	6,514
Balboa West	304.6	31	516	718	0	0	2,130.4	3,700
Piña / Ft. Sherman	7,788.6	3.4	154	1,175.0	362.0	233.0	0	9,716

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The values presented in Table 12-1 represents a snapshot in time of the current conditions of the Ranges and Training Area with respect to UXO concentrations. As UXO removal and sampling operations continue on the ranges the UXO assessments will change.

## **SOURCES USED**

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McLane, Major ACC/CEXE. 1998. E-mail to Jonathan Sperka (NAVEODTECHDIV) Regarding Balboa West Data. May 1998.

Naval EOD Technology Division (NAVEODTECHDIV). 1997. "Unexploded Ordnance Assessment of U.S. Military Ranges in Panama: Empire, Balboa West and Piña Ranges." NAVEODTECHDIV Indian Head, MD. January 1997.

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The Nature Conservancy (TNC) and National Association for the Conservation of Nature (ANCON) 1994. "Rapid Ecological Assessment of Lands in Panama Managed by the U.S. Department of Defense." December 1994.

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U.S. Army Environmental Center (USAEC) 1996. "Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase II)." USACE Aberdeen Proving Ground, MD, June 1996.

(USAEC) 1997. "Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase III)." USACE Aberdeen Proving Ground, MD, 1997.

U.S. Department of Defense (DoD) 1995. "DoD Ammunition and Explosives Safety Standards, DoD 6055.9-STD." October 1995.

## **Appendix A – Points of Contact**

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Points of Contact (POC) for various organizations that conducted Site Investigation activities on the Empire, Balboa West and Piña Ranges and provided data for this report.

Panama Canal Treaty Implementation Agency (TIPA)  
HQDA SAUS-IA-TP 102  
Army Pentagon 20310-0102  
ATTN: CDR Davis

U.S. Army South (USARSO)  
DSEN-SOEN, Unit 7112,  
Building 95, Room 298  
Fort Clayton, Panama 34004  
ATTN: COL Debow

U.S. Army Environmental Center (USAEC)  
Installation Restoration Division  
Aberdeen Proving Ground MD 21010-5401  
ATTN: Heather Black

Naval EOD Technology Division (NAVEODTECHDIV)  
Commanding Officer  
2008 Stump Neck Road  
Indian Head, MD 20640  
ATTN: Jonathan Sperka 50A27

U.S. Army Engineering and Support Center (USACE)  
P.O. Box 1600  
Huntsville, Alabama 35807  
ATTN: CEHNC-OE-DC-A (Mr. Belew)

Task Force 111 EOD  
2499 Johnson Road SW  
Huntsville, AL 35805-5834  
ATTN: LT COL Hoover

USAF Installation Logistics Environmental Restoration (ILEVR)  
HQUSAF/ILEVR  
1235 Jefferson Davis Hwy, Suite 1000  
Arlington, VA 22202  
ATTN: Mr. Furlong

U.S. Southern Command Center For Treaty Implementation (SCTI)  
HQ SOUTHCOM -SCTI,  
Unit 7142, Building 9  
Corazal East, Panama 34004  
ATTN: NICO Degreef

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## Appendix B

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### Target No: 2

**Photograph No:** 41

**Description:** 155-mm M549

**Depth:** 2.00 meters bgs

**Azimuth:** North

**Declination:** Flat

**Northing:** 189.90

**Easting:** 924.20



### Target No: 3

**Photograph No:** 42

**Description:** 100-lb bomb GP old style

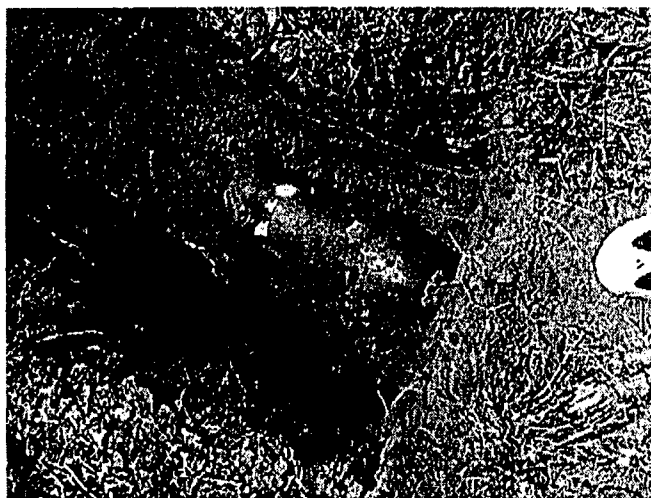
**Depth:** 0.80 meter bgs

**Azimuth:** North

**Declination:** Nose Up 45°

**Northing:** 182.42

**Easting:** 9917.86

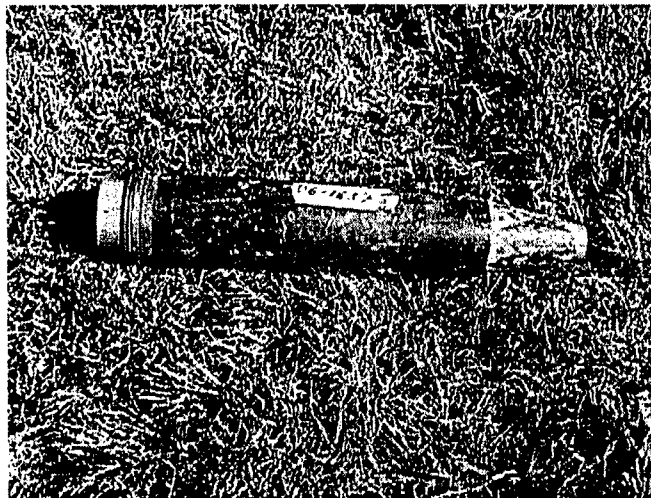


### Target No: 4

**Photograph No:** 4

**Description:** 155-mm projectile without fuze

**Weight:** 54.50 lb



**Target No: 4**

**Photograph No: 4**

**Description:** 155-mm projectile without fuze

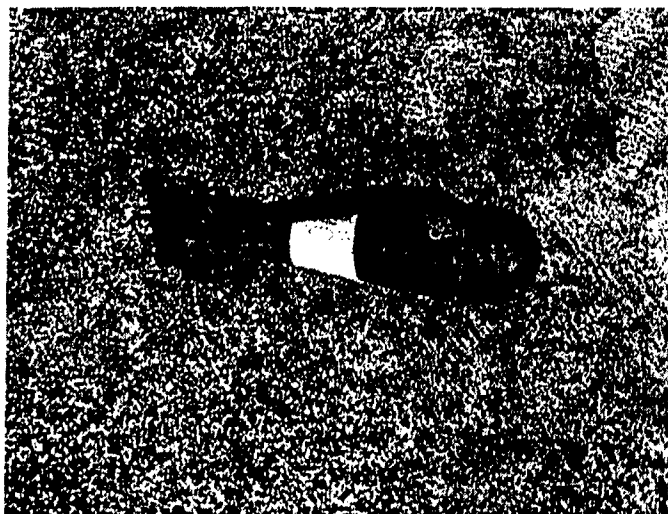
**Depth:** 1.20 meters bgs

**Azimuth:** North

**Declination:** Nose Down 45°

**Northing:** 183.38

**Easting:** 932.69



**Target No: 5**

**Photograph No: 5**

**Description:** 155-mm projectile with fuze

**Weight:** 52.50 lb

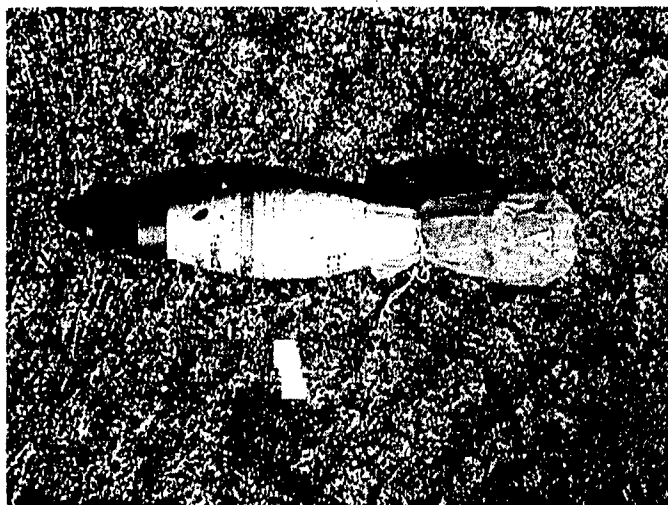


**Target No: 6**

**Photograph No: 16**

**Description:** 60-mm mortar

**Weight:** 3.80 lb

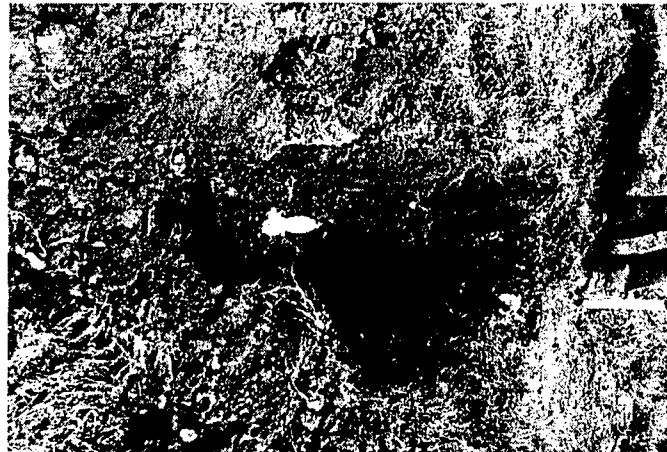


**Target No. 7**

**Photograph No: 7**

**Description: 81-mm mortar**

**Weight: 10.50 lb**



**Target No. 7**

**Photograph No: 30**

**Description: 81-mm mortar**

**Depth: 1.00 meter bgs**

**Azimuth: North**

**Declination: Flat**

**Northing: 182.42**

**Easting: 909.84**

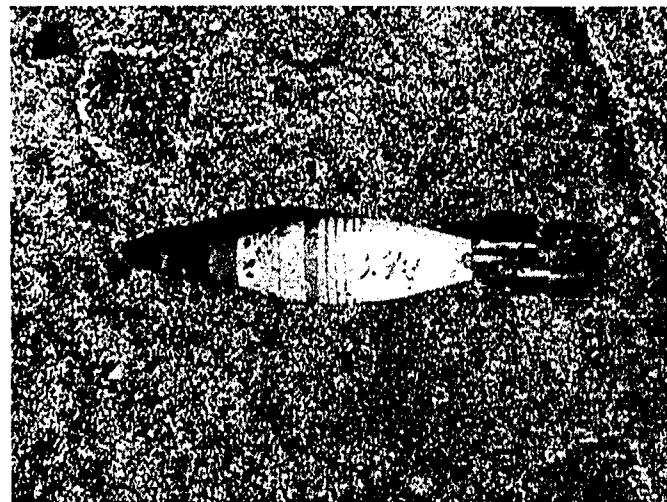


**Target No. 8**

**Photograph No: 17**

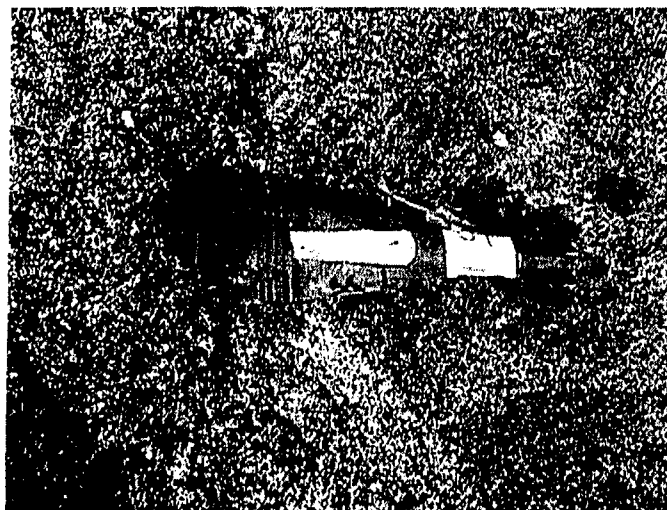
**Description: 60-mm mortar**

**Weight: 3.75 lb**



**Target No: 8**

**Photograph No:** 28  
**Description:** 60-mm mortar  
**Depth:** 1.00 meter bgs  
**Azimuth:** North  
**Declination:** Flat  
**Northing:** 177.94  
**Easting:** 910.46



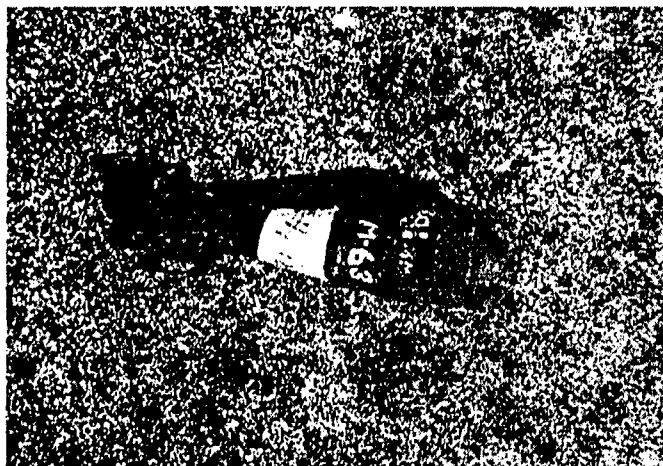
**Target No. 8**

**Photograph No:** 29  
**Description:** 60-mm mortar  
**Depth:** 1.00 meter bgs  
**Azimuth:** North  
**Declination:** Flat  
**Northing:** 177.94  
**Easting:** 910.46



**Target No. 9**

**Photograph No:** 8  
**Description:** 81-mm mortar  
**Weight:** 10.25 lb

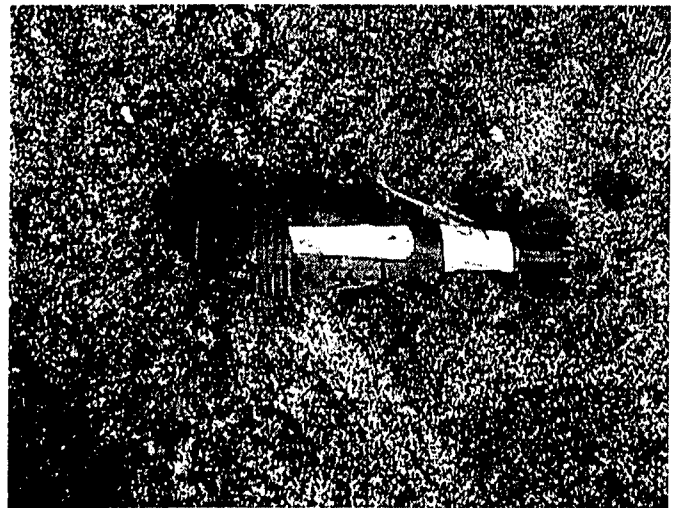


**Target No. 11**

**Photograph No: 11**

**Description: 82-mm mortar**

**Weight: 5.75 lb**



**Target No. 11**

**Photograph No: 34**

**Description: 82-mm mortar**

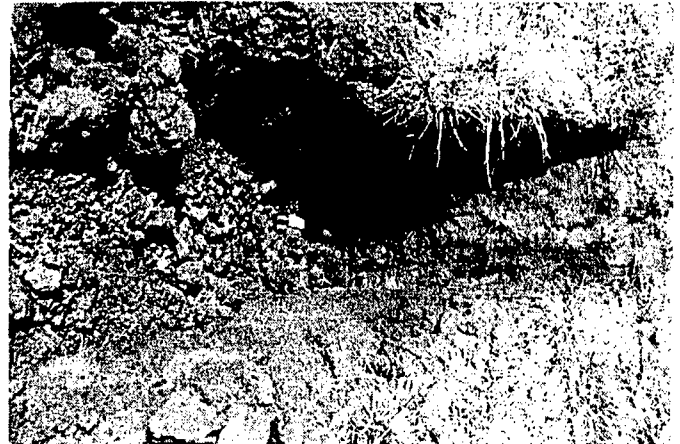
**Depth: 1.30 meters bgs**

**Azimuth: North**

**Declination: Nose Up 45°**

**Northing: 167.75**

**Easting: 919.18**



**Target No. 12**

**Photograph No: 26**

**Description: 60-mm mortar**

**Depth: 1.00 meter bgs**

**Azimuth: North**

**Declination: Flat**

**Northing: 172.45**

**Easting: 920.48**

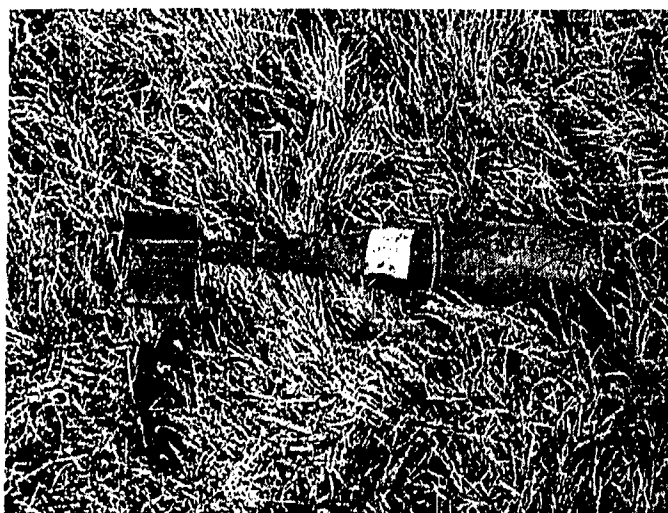


**Target No. 13**

**Photograph No: 6**

**Description:** BDU-33 practice bomb

**Weight:** 23.25 lb



**Target No. 13**

**Photograph No: 23**

**Description:** BDU-33

**Depth:** 1.20 meters below ground surface (bgs)

**Azimuth:** North

**Declination:** Flat

**Northing:** 175.59

**Easting:** 918.18

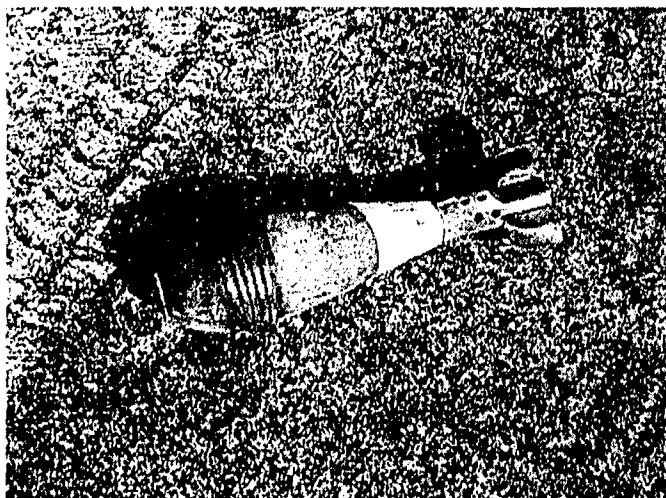


**Target No. 14**

**Photograph No: 12**

**Description:** 82-mm mortar

**Weight:** 5.50 lb



**Target No. 14**

**Photograph No:** 24

**Description:** 82-millimeter (mm) mortar

**Depth:** 0.50 meter bgs

**Azimuth:** North

**Declination:** Nose Down 45°

**Northing:** 179.01

**Easting:** 922.62



**Target No. 15**

**Photograph No:** 33

**Description:** 82-mm mortar

**Depth:** 2.00 meters bgs

**Azimuth:** North

**Declination:** Flat

**Northing:** 174.21

**Easting:** 929.59

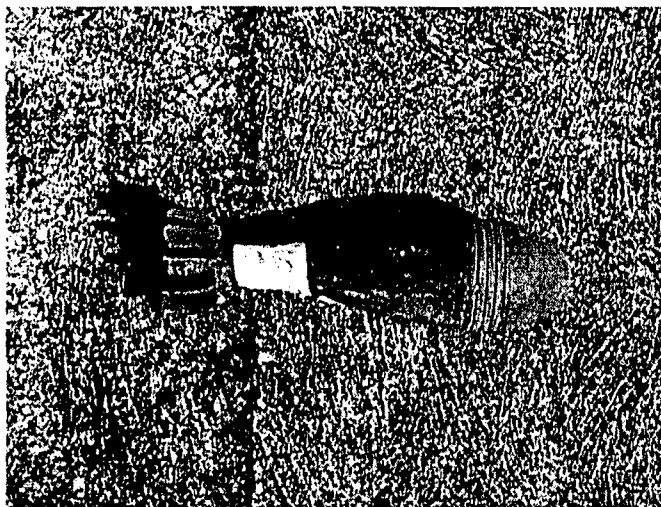


**Target No. 16**

**Photograph No:** 13

**Description:** 82-mm mortar

**Weight:** 5.75 lb



**Target No. 16**

**Photograph No:** 32

**Description:** 82-mm mortar

**Depth:** 1.00 meter bgs

**Azimuth:** North

**Declination:** Nose Down 45°

**Northing:** 176.87

**Easting:** 935.35



**Target No 17**

**Photograph No:** 31

**Description:** 60-mm mortar

**Depth:** 0.50 meter bgs

**Azimuth:** North

**Declination:** Nose Down 45°

**Northing:** 177.90

**Easting:** 930.97

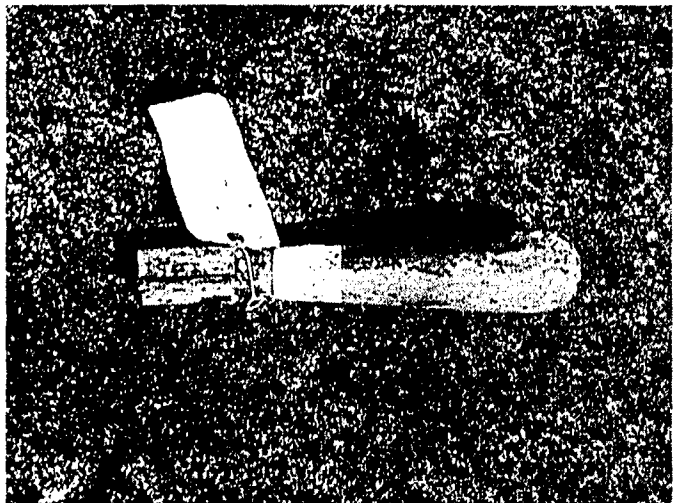


**Target No. 19**

**Photograph No:** 9

**Description:** Mark 19 practice bomb

**Weight:** 12.75 lb



**Target No. 19**

**Photograph No:** 25

**Description:** Mark 19 practice bomb

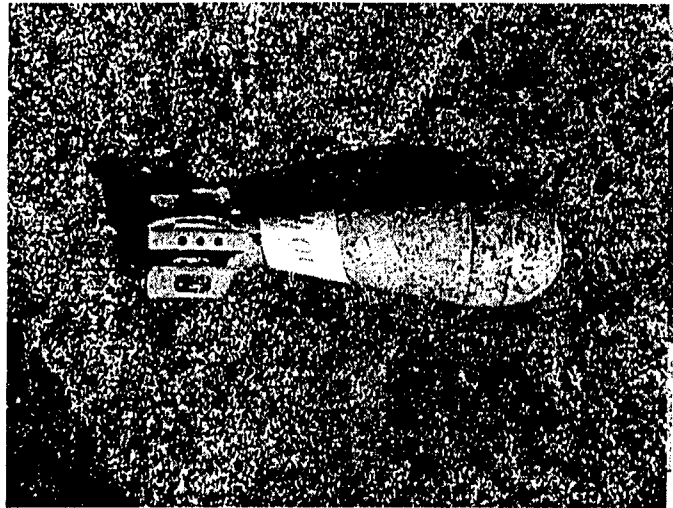
**Depth:** 1.00 meter bgs

**Azimuth:** North

**Declination:** Nose Down 45°

**Northing:** 183.72

**Easting:** 926.03



**Target No. 20**

**Photograph No:** 27

**Description:** 60-mm mortar

**Depth:** 0.25 meter bgs

**Azimuth:** North

**Declination:** Nose Up 45°

**Northing:** 187.66

**Easting:** 928.56

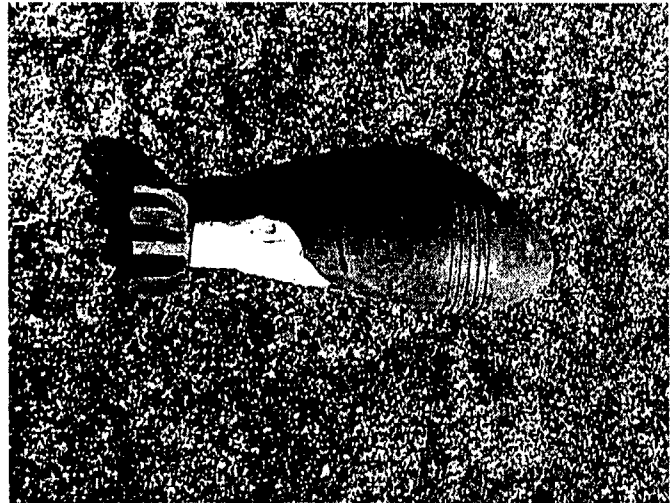


**Target No. 21**

**Photograph No:** 14

**Description:** 82-mm mortar

**Weight:** 5.50 lb

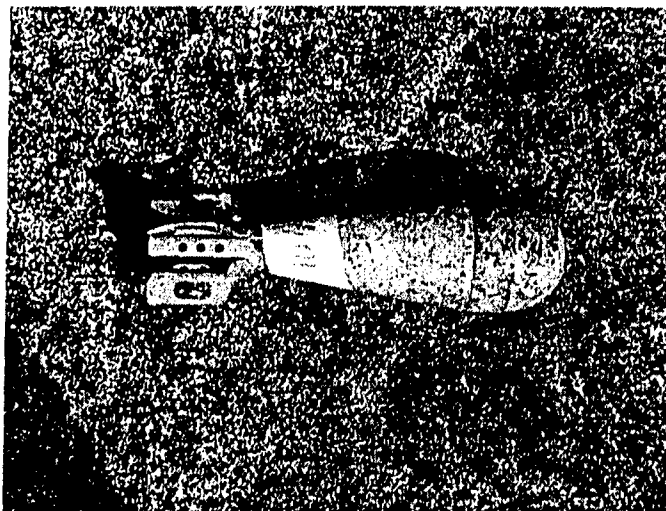


**Target No. 23**

**Photograph No: 10**

**Description: 81-mm mortar**

**Weight: 10.50 lb**

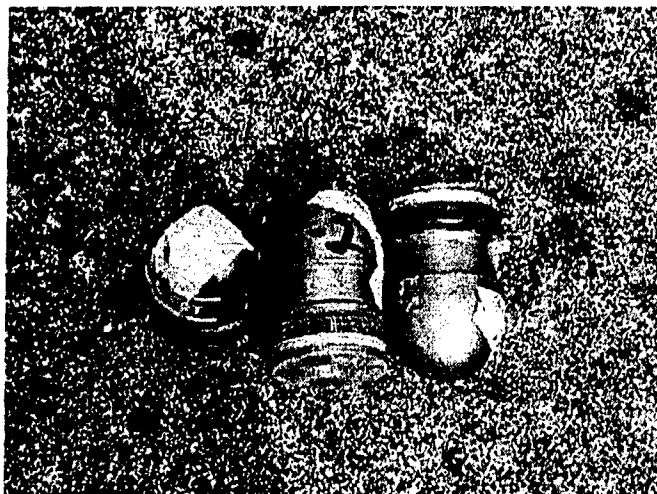


**Targets No. 24, 25, and 33**

**Photograph No: 22**

**Description: 40-mm grenade (three)  
with base, without cartridge M385**

**Weight: 0.50 lb**



**Target No. 27**

**Photograph No: 15**

**Description: 40-mm M385E4**

**Weight: 0.50 lb**

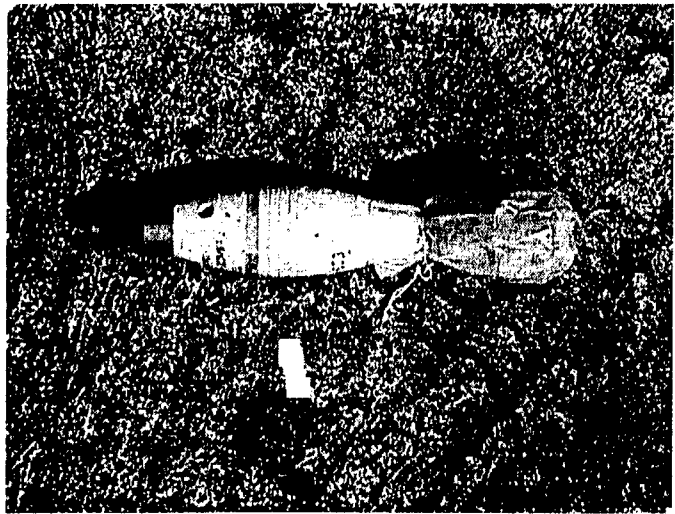


**Target No. 27**

**Photograph No: 19**

**Description:** 40-mm grenade M385E4

**Weight:** 0.50 lb



**Target No. 28**

**Photograph No: 20**

**Description:** 40-mm grenade  
without cartridge M385

**Weight:** 0.25 lb

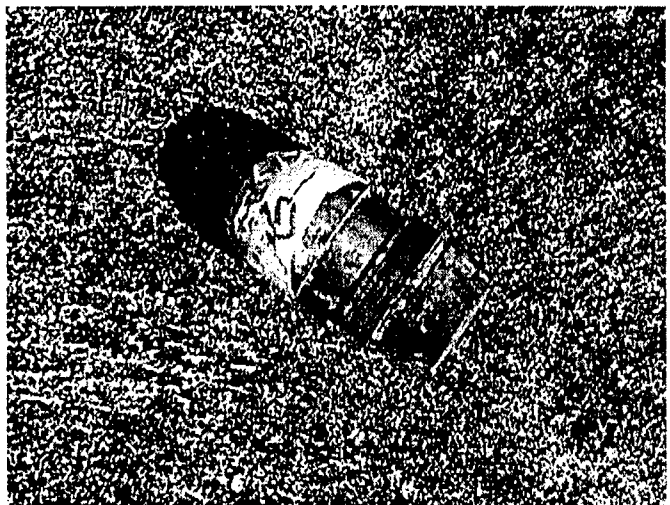


**Target No. 30**

**Photograph No: 21**

**Description:** 40-mm grenade  
with base, without cartridge M385E4

**Weight:** 0.60 lb

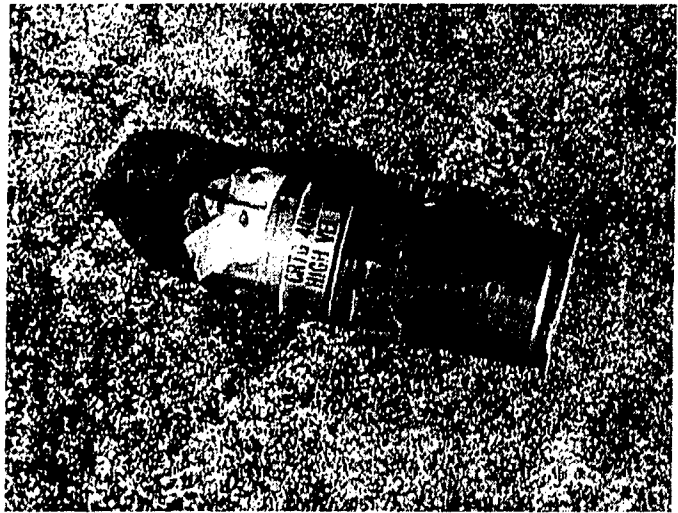


**Target No. 31**

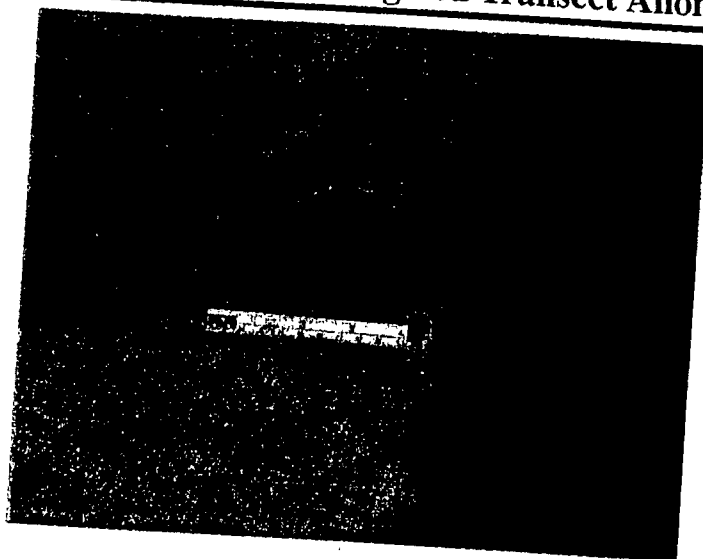
**Photograph No: 18**

**Description:** 40-mm grenade  
with cartridge XM922

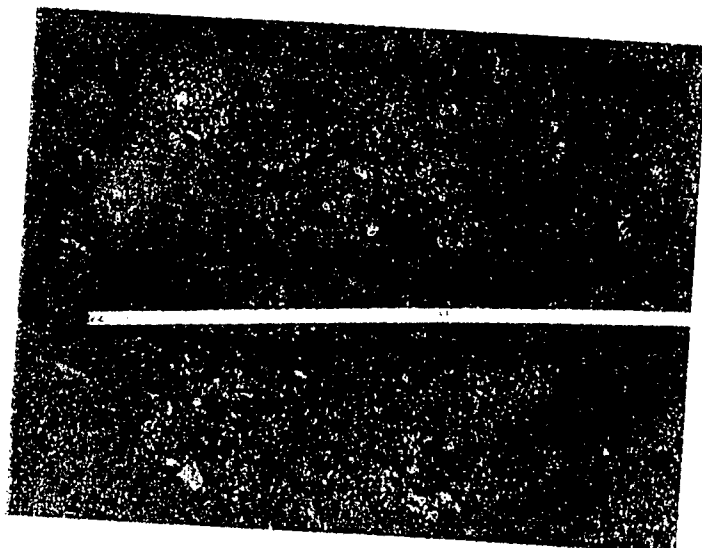
**Weight:** 0.75 lb



## Appendix C – Interrogated Transect Anomalies

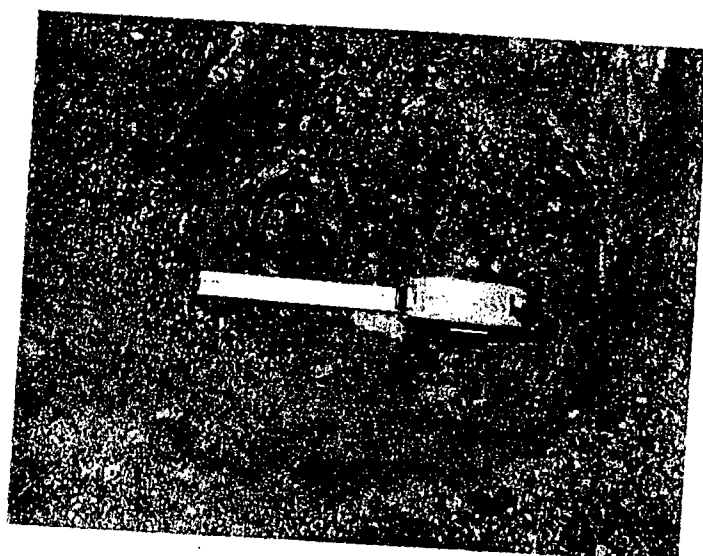


<b>Transect:</b>	<b>A1-2</b>
<b>Description:</b>	<b>Frag.</b>
<b>Picture #:</b>	<b>P000833.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>10.16 cm</b>
<b>Width:</b>	<b>5.08 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>318.93 grams</b>



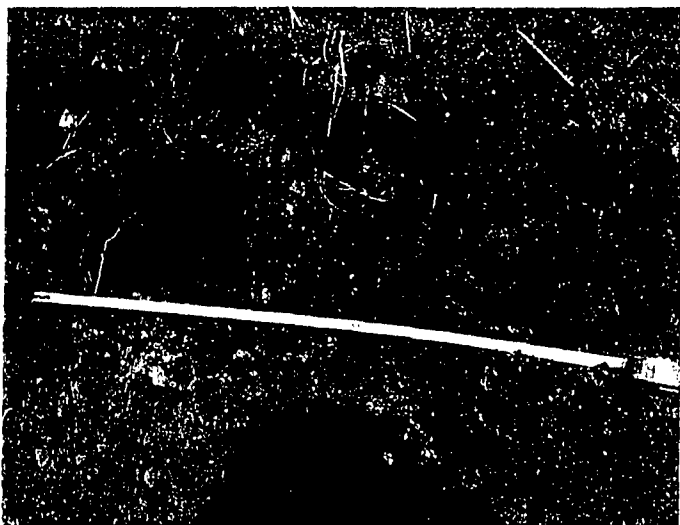
<b>Transect:</b>	<b>C1-5</b>
<b>Description:</b>	<b>BDU33</b>
<b>Picture #:</b>	<b>P000817.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>

<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>

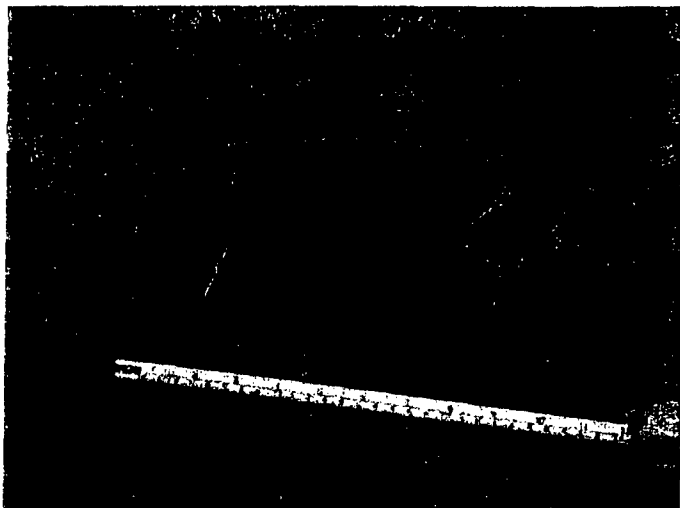


<b>Transect:</b>	<b>C1-6</b>
<b>Description:</b>	<b>Frag.</b>
<b>Picture #:</b>	<b>P000818.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>

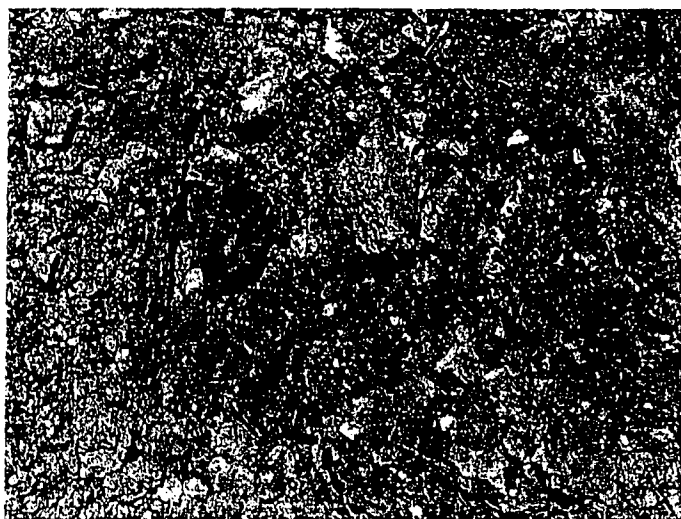
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



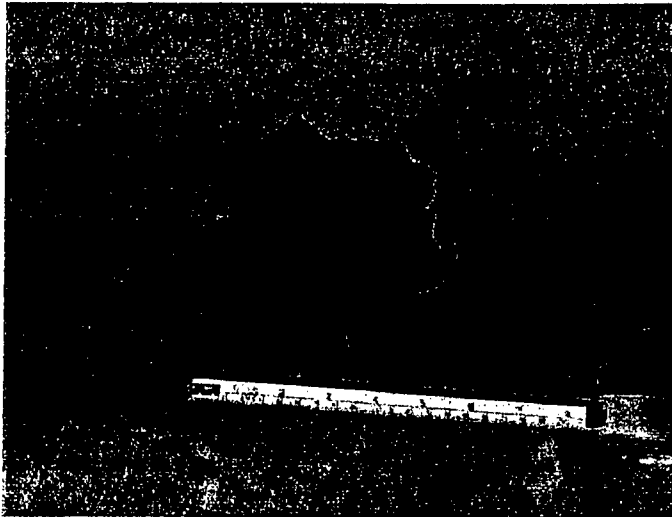
**Transect:** C1-9  
**Description:** Frag, pipe, M16  
cartridge  
**Picture #:** P000819.jpg  
**Depth:** < 25 cm  
  
**Length:** 20.32, 21.59 cm  
**Width:** 12.70, 2.54 cm  
**Thickness:** 1.27, 2.54 cm  
**Weight:** 1247.36, 354.36  
grams



**Transect:** C1-10  
**Description:** Frag  
**Picture #:** P000831.jpg  
**Depth:** < 25 cm  
  
**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** C2-1  
**Description:** nail, cart. links  
**Picture #:** P000815.jpg  
**Depth:** < 25 cm  
  
**Length:** 8.26, 2.54 cm  
**Width:** .95, 2.54 cm  
**Thickness:** .95, 2.54 cm  
**Weight:** 14.18 grams (total)



**Transect:** C2-2  
**Description:** Frag  
**Picture #:** P000835.jpg  
**Depth:** < 25 cm

**Length:** 12.07 cm  
**Width:** 13.34 cm  
**Thickness:** .64 cm  
**Weight:** 283.49 grams



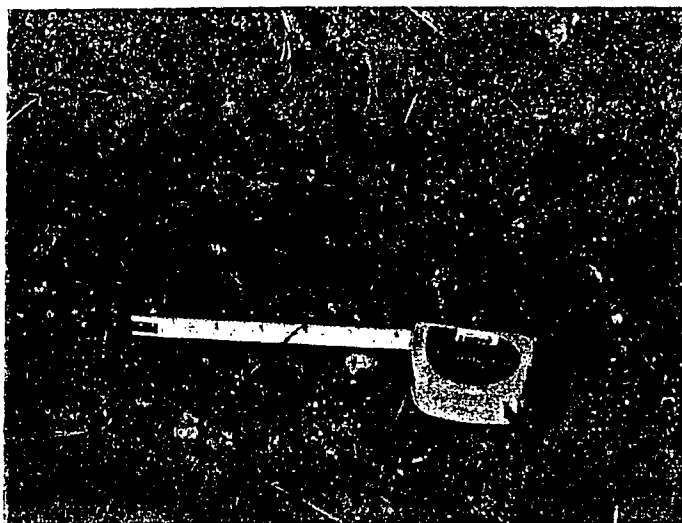
**Transect:** C2-3  
**Description:** Fuze Component  
**Picture #:** P000814.jpg  
**Depth:** < 25 cm

**Length:** 10.16 cm  
**Width:** 5.08 cm  
**Thickness:** 5.08 cm  
**Weight:** 184.27 grams



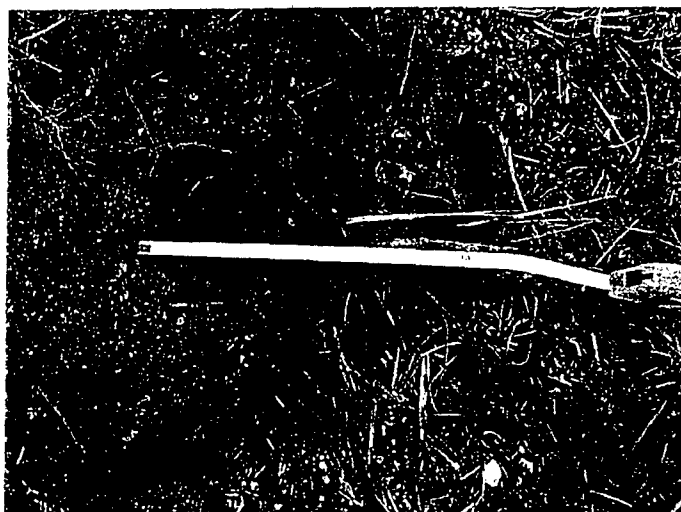
**Transect:** C2-4  
**Description:** Grenade Spoon  
**Picture #:** P000813.jpg  
**Depth:** < 25 cm

**Length:** 12.70 cm  
**Width:** 1.27 cm  
**Thickness:** .16 cm  
**Weight:** 14.18 grams



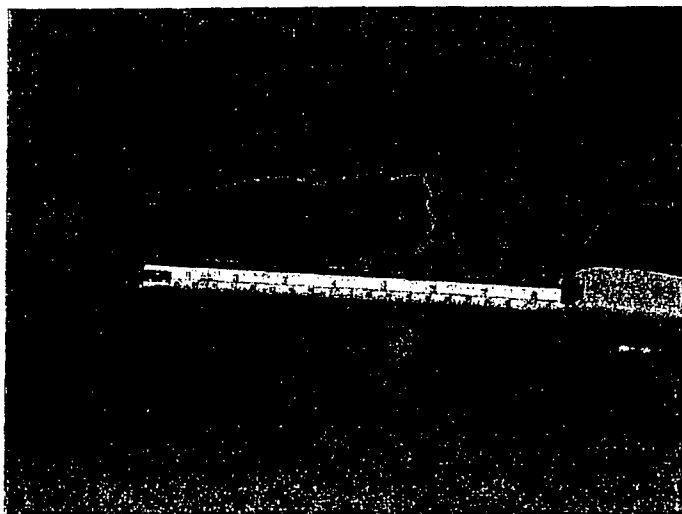
**Transect:** C2-7  
**Description:** Frag  
**Picture #:** P000820.jpg  
**Depth:** < 25 cm

**Length:** 12.7 cm  
**Width:** 6.35 cm  
**Thickness:** 2.22 cm  
**Weight:** 498.94 grams



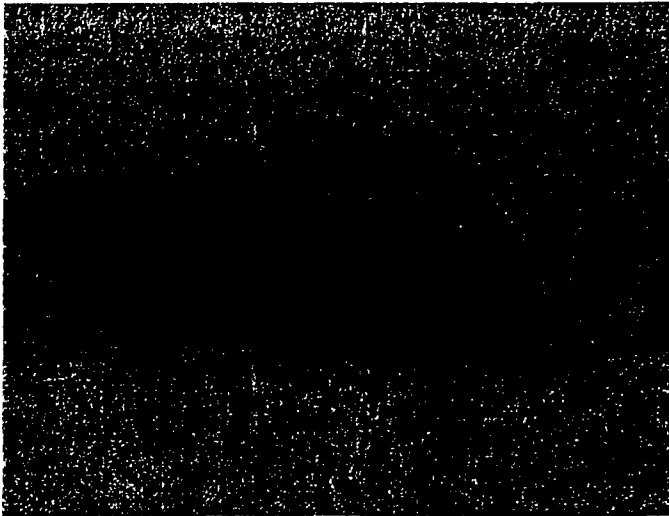
**Transect:** C2-8  
**Description:** pipe and rock  
**Picture #:** P000821.jpg  
**Depth:** < 25 cm

**Length:** 35.56 cm  
**Width:** 2.54 cm  
**Thickness:** 2.54 cm  
**Weight:** 544.30 grams



**Transect:** C2-9  
**Description:** Frag  
**Picture #:** P000834.jpg  
**Depth:** < 25 cm

**Length:** 5.08 cm  
**Width:** 13.97 cm  
**Thickness:** .953 cm  
**Weight:** 240.97 grams



**Transect:** C3-1  
**Description:** Frag  
**Picture #:** P000807.jpg  
**Depth:** < 25 cm

**Length:** 12.7 cm  
**Width:** 5.08 cm  
**Thickness:** .64 cm  
**Weight:** 212.62 grams

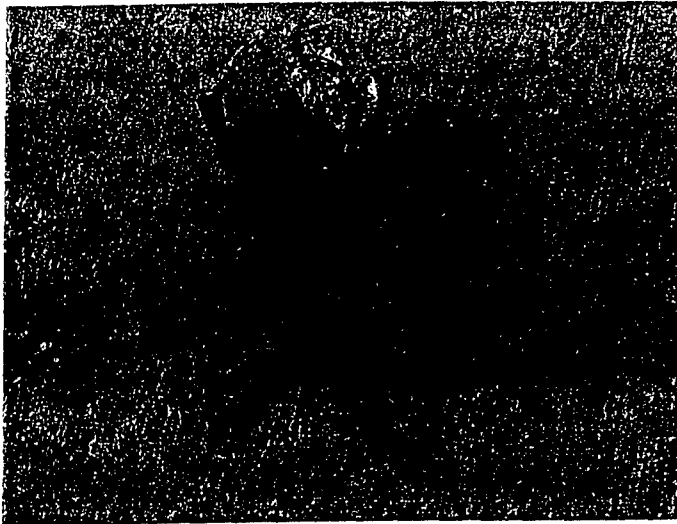


**Transect:** C4-1  
**Description:** 3.5" rocket motor,  
rocks  
**Picture #:** P000797.jpg  
**Depth:** < 25 cm

**Length:** 26.67 cm  
**Width:** 8.89 cm  
**Thickness:** 8.89 cm  
**Weight:** 1700.94 grams

**Transect:** C4-6  
**Description:** Frag (3 pieces)  
**Picture #:** P000797.jpg  
**Depth:** < 25 cm

**Length:** 17.78, 7.62, 10.16 cm  
**Width:** 5.40, 5.08, 3.81 cm  
**Thickness:** .95, 1.27, .95 cm  
**Weight:** 425.24, 240.97,  
170.09 grams



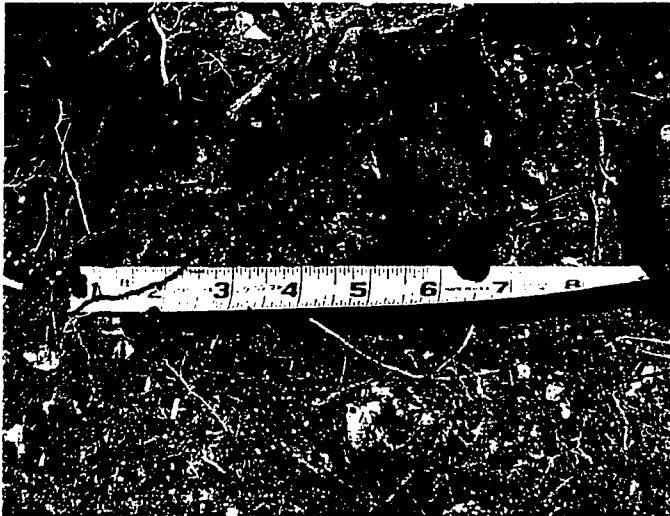
<b>Transect:</b>	<b>C4-3</b>
<b>Description:</b>	<b>81mm fuze components</b>
<b>Picture #:</b>	<b>P000808.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>680.38 grams</b>



<b>Transect:</b>	<b>C5-1</b>
<b>Description:</b>	<b>Magnetic Rock</b>
<b>Picture #:</b>	<b>P000798.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



<b>Transect:</b>	<b>C5-2</b>
<b>Description:</b>	<b>Electrical Terminals</b>
<b>Picture #:</b>	<b>P000799.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>4.76 cm</b>
<b>Width:</b>	<b>3.18 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>63.79 grams</b>



**Transect:** C5-3  
**Description:** Reinforced  
Concrete  
**Picture #:** P000800.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** C5-4  
**Description:** Flare Holder,  
rocks  
**Picture #:** P000801.jpg  
**Depth:** < 25 cm

**Length:** 8.89 cm  
**Width:** 6.35 cm  
**Thickness:** 5.72 cm  
**Weight:** 141.75 grams



**Transect:** C5-5  
**Description:** Fence Wire  
**Picture #:** P000802.jpg  
**Depth:** < 25 cm

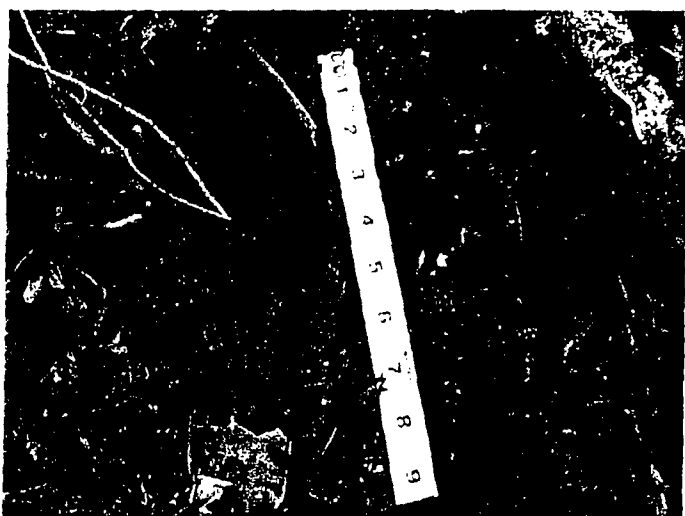
**Length:** 60.96 cm  
**Width:** .48 cm  
**Thickness:** .48 cm  
**Weight:** 113.40 grams

**Transect:** C5-6  
**Description:** Fence Wire  
**Picture #:** No picture  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** 63.79 grams

**Transect:** C6-1  
**Description:** Frag  
**Picture #:** No Picture  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** C6-2  
**Description:** Fuze, wire  
**Picture #:** P000803.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



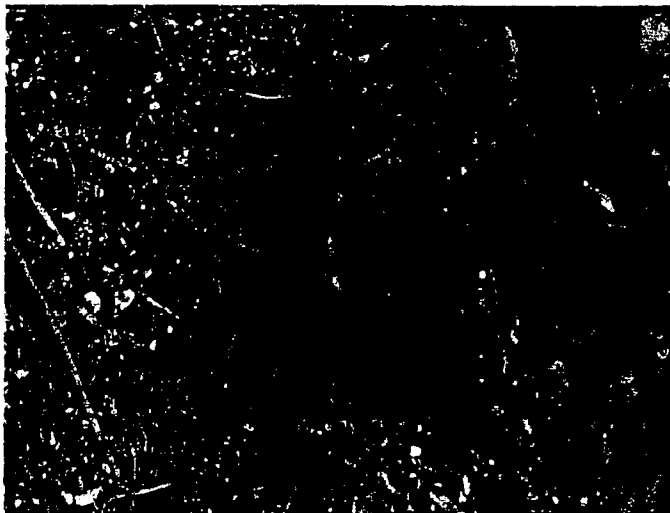
**Transect:** C6-3  
**Description:** Fuze  
**Picture #:** P000804.jpg  
**Depth:** < 25 cm

**Length:** 6.03 cm  
**Width:** 4.45 cm  
**Thickness:** 1.27 cm  
**Weight:** 56.70 grams



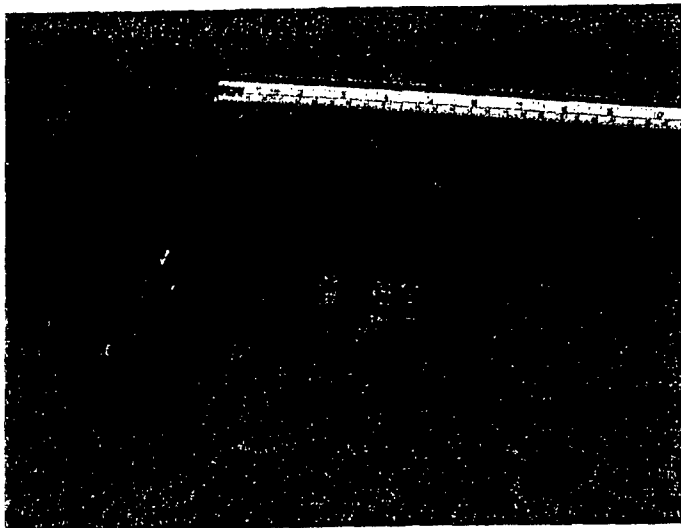
**Transect:** C6-4  
**Description:** Frag  
**Picture #:** P000805.jpg  
**Depth:** < 25 cm

**Length:** 15.24 cm  
**Width:** 16.51 cm  
**Thickness:** .64 cm  
**Weight:** 765.42 grams



**Transect:** C8-1  
**Description:** Base Plate  
106mm recoilless  
**Picture #:** P000806.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** Camp Bayonet  
**Description:** 2.75" rocket head  
**Picture #:** P000836.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA

**Transect:**  
**Description:**  
**Picture #:** P000806.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA

**Transect:**  
**Description:**  
**Picture #:** P000806.jpg  
**Depth:** < 25 cm

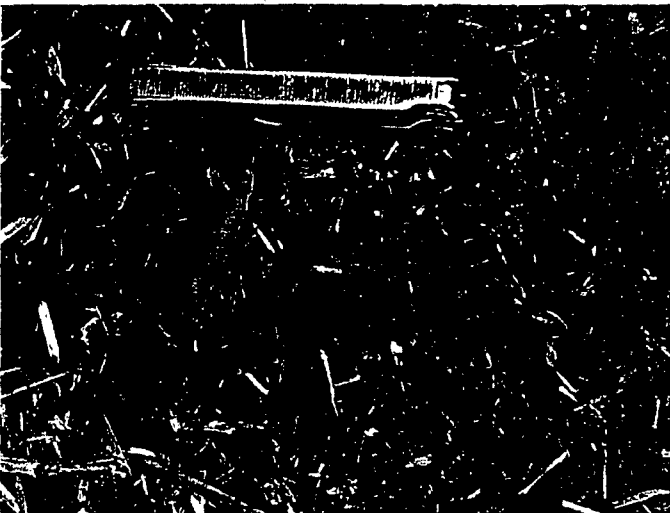
**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



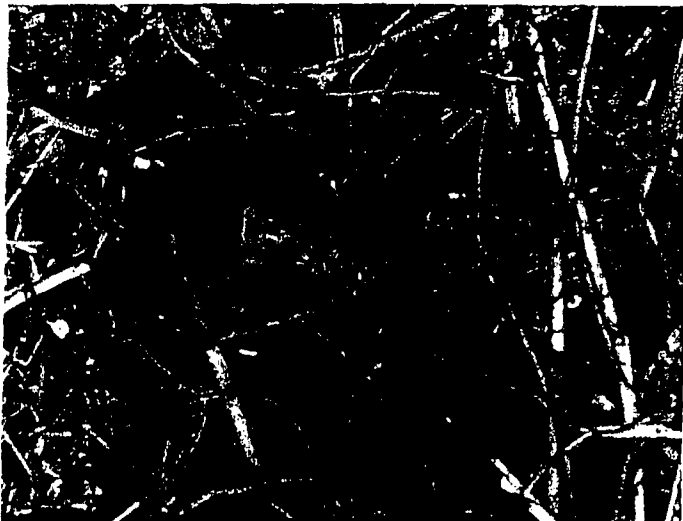
<b>Transect:</b>	<b>F1-1</b>
<b>Description:</b>	<b>Cartridge Links</b>
<b>Picture #:</b>	<b>P000783.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



<b>Transect:</b>	<b>F1-2</b>
<b>Description:</b>	<b>M16 Casings</b>
<b>Picture #:</b>	<b>P000784.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>

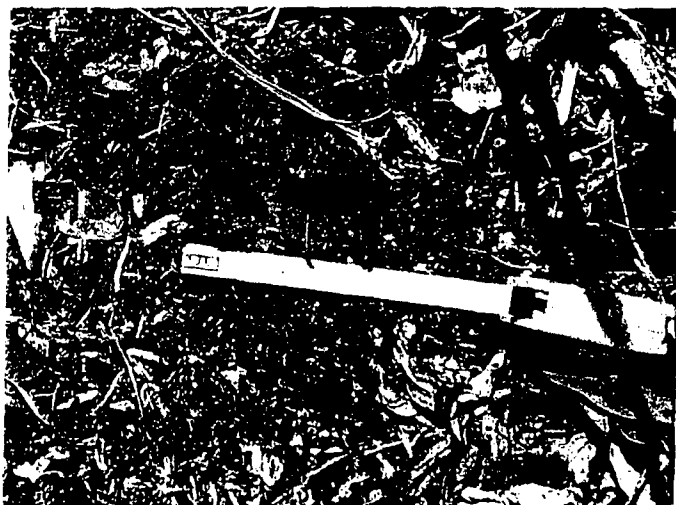


<b>Transect:</b>	<b>F1-3</b>
<b>Description:</b>	<b>M16 Blanks</b>
<b>Picture #:</b>	<b>P000785.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



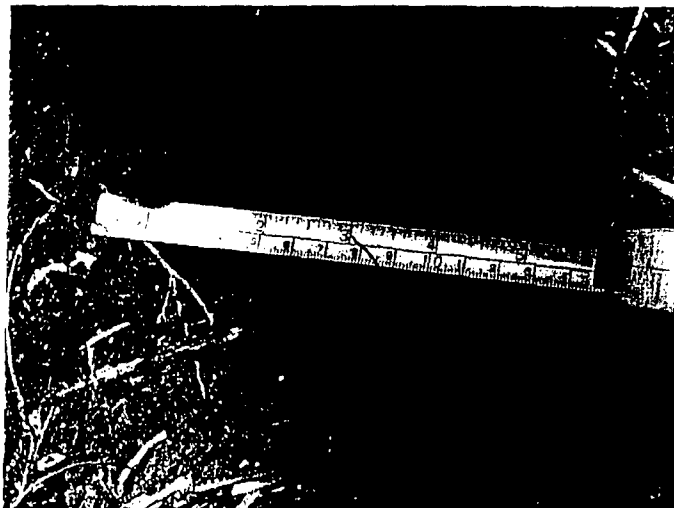
**Transect:** G8-1  
**Description:** Beer Can  
**Picture #:** P000786.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



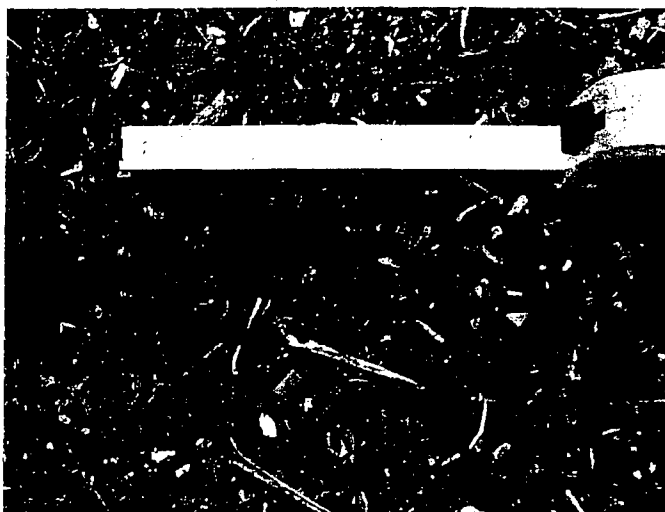
**Transect:** H4-2  
**Description:** 20mm Links  
**Picture #:** P000788.jpg  
**Depth:** < 25 cm

**Length:** 8.26 cm  
**Width:** 7.62 cm  
**Thickness:** 3.18 cm  
**Weight:** 42.52 grams



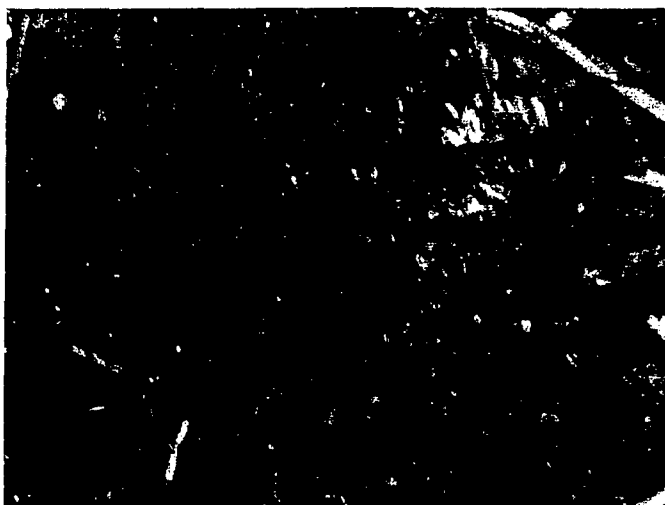
**Transect:** H4-3  
**Description:** Frag  
**Picture #:** P000789.jpg  
**Depth:** < 25 cm

**Length:** 10.16 cm  
**Width:** 3.18 cm  
**Thickness:** .95 cm  
**Weight:** 148.83 grams



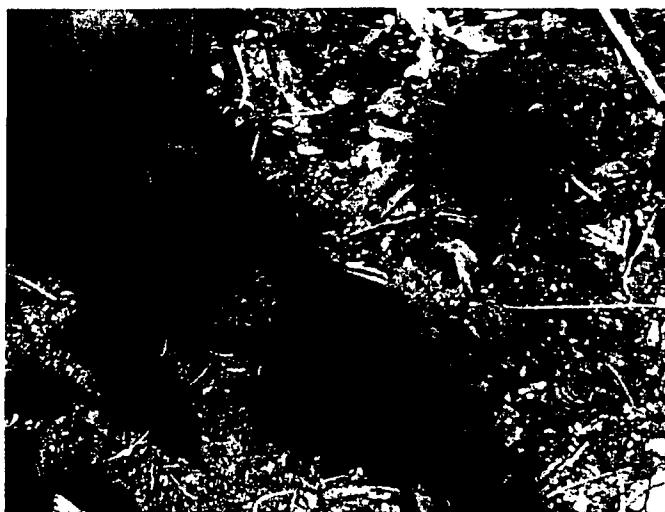
**Transect:** H4-4  
**Description:** Frag  
**Picture #:** P000790.jpg  
**Depth:** < 25 cm

**Length:** 6.35 cm  
**Width:** 2.54 cm  
**Thickness:** .95 cm  
**Weight:** 49.61 grams



**Transect:** J2-1  
**Description:** 20mm Cartridge  
**Picture #:** P000791.jpg  
**Depth:** < 25 cm

**Length:** 10.16 cm  
**Width:** 3.18 cm  
**Thickness:** 3.18 cm  
**Weight:** 113.4 grams



**Transect:** J8-1  
**Description:** 20mm Cart., Links  
**Picture #:** P000793.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** 85.05 grams (total)



**Transect:** J9-1  
**Description:** 2.75" Rocket Fin  
**Picture #:** P000795.jpg  
**Depth:** < 25 cm

**Length:** 15.24 cm  
**Width:** 3.18 cm  
**Thickness:** .32 cm  
**Weight:** 42.52 grams



**Transect:** L1-1  
**Description:** Steel Milk Crate  
**Picture #:** P000745.jpg  
**Depth:** < 25 cm

**Length:** 39.37 cm  
**Width:** 33.02 cm  
**Thickness:** 29.85 cm  
**Weight:** >2.2 kg



<b>Transect:</b>	<b>M2-1</b>
<b>Description:</b>	<b>M16 Magazine w/blanks</b>
<b>Picture #:</b>	<b>P000746.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



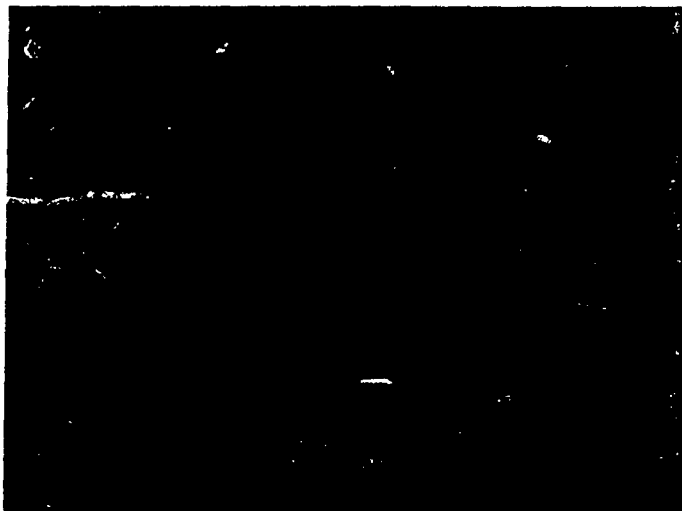
<b>Transect:</b>	<b>P7-1</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000755.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>10.16 cm</b>
<b>Width:</b>	<b>5.72 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>269.32 grams</b>



<b>Transect:</b>	<b>P7-2</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000756.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>7.62 cm</b>
<b>Width:</b>	<b>3.18 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>92.13 grams</b>



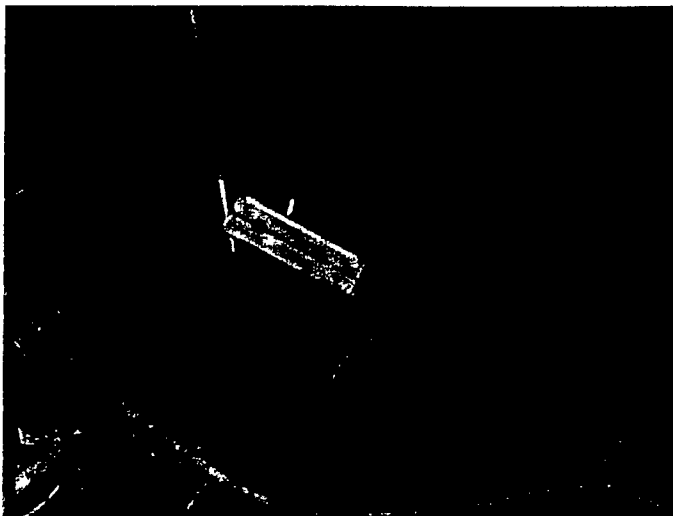
<b>Transect:</b>	<b>P7-3</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000754.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>15.24 cm</b>
<b>Width:</b>	<b>6.99 cm</b>
<b>Thickness:</b>	<b>1.91 cm</b>
<b>Weight:</b>	<b>680.38 grams</b>



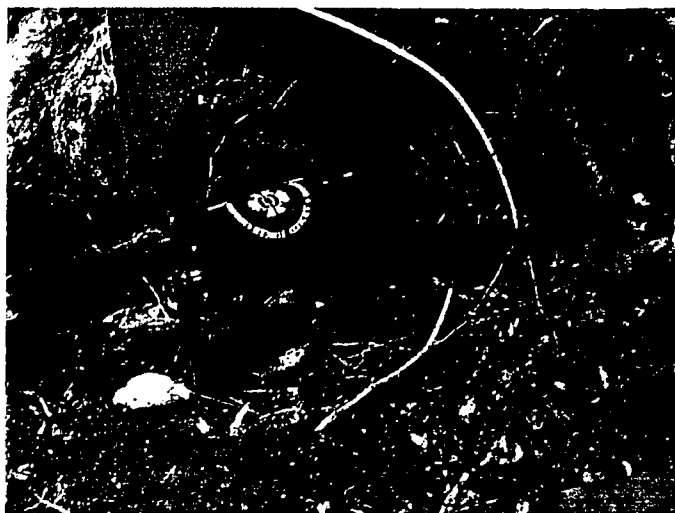
<b>Transect:</b>	<b>P8-1</b>
<b>Description:</b>	<b>105mm Base Plate</b>
<b>Picture #:</b>	<b>P000757.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>10.5 cm</b>
<b>Width:</b>	<b>10.5 cm</b>
<b>Thickness:</b>	<b>3.0 cm</b>
<b>Weight:</b>	<b>1,332.4 grams</b>



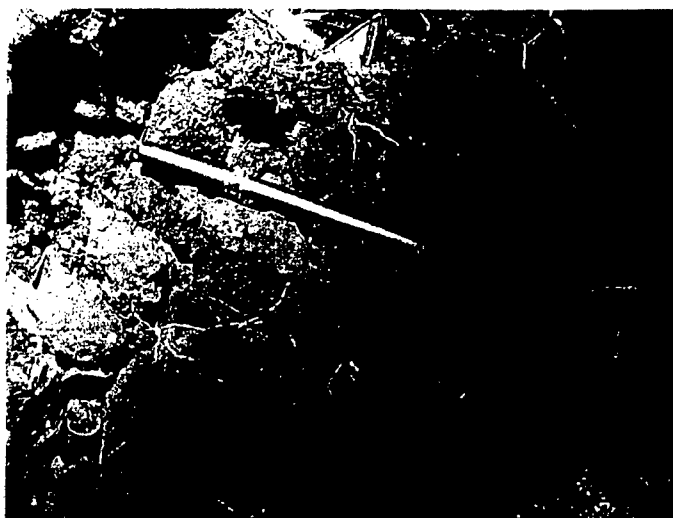
<b>Transect:</b>	<b>P8-2</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000758.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>10.48 cm</b>
<b>Width:</b>	<b>6.35 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>269.32 grams</b>



<b>Transect:</b>	<b>P8-3</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000759.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>10.80 cm</b>
<b>Width:</b>	<b>3.18cm</b>
<b>Thickness:</b>	<b>1.91 cm</b>
<b>Weight:</b>	<b>155.92 grams</b>



<b>Transect:</b>	<b>P8-4</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000760.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



<b>Transect:</b>	<b>P9-1</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000761.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>
<b>Length:</b>	<b>8.26 cm</b>
<b>Width:</b>	<b>2.54 cm</b>
<b>Thickness:</b>	<b>1.27 cm</b>
<b>Weight:</b>	<b>56.70 grams</b>



**Transect:** P13-1  
**Description:** Frag  
**Picture #:** P000762.jpg  
**Depth:** < 25 cm

**Length:** 5.08 cm  
**Width:** 2.54 cm  
**Thickness:** 1.27 cm  
**Weight:** 35.44 grams

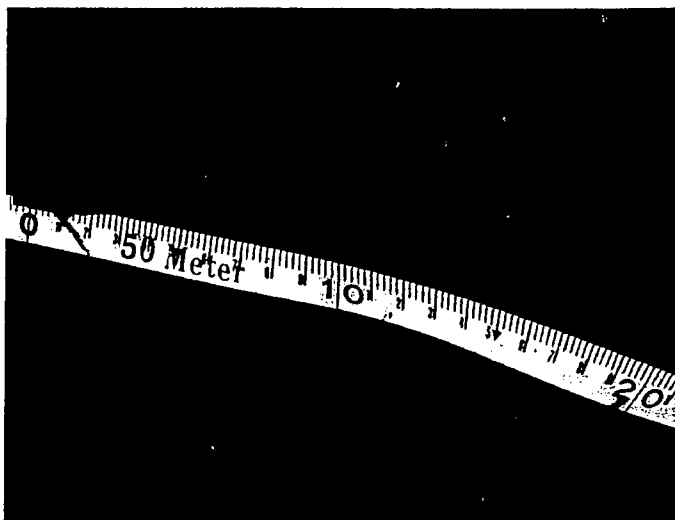
**Transect:** P13-2  
**Description:** Frag  
**Picture #:** no picture  
**Depth:** < 25 cm

**Length:** 13.97 cm  
**Width:** 3.18 cm  
**Thickness:** 1.27 cm  
**Weight:** 205.53 grams



**Transect:** P6-1  
**Description:** Battery  
**Picture #:** P000764.jpg  
**Depth:** < 25 cm

**Length:** 5.72 cm  
**Width:** 3.81 cm  
**Thickness:** 3.81 cm  
**Weight:** 85.05 grams



**Transect:** P13-2  
**Description:** Frag  
**Picture #:** P000763.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** E1-1  
**Description:** Frag  
**Picture #:** P000809.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



**Transect:** E2-1  
**Description:** Frag  
**Picture #:** P000810.jpg  
**Depth:** < 25 cm

**Length:** NA  
**Width:** NA  
**Thickness:** NA  
**Weight:** NA



<b>Transect:</b>	<b>E3-1</b>
<b>Description:</b>	<b>Frag</b>
<b>Picture #:</b>	<b>P000811.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>

<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>



<b>Transect:</b>	<b>C2-6</b>
<b>Description:</b>	<b>Frag,link,.233 blanks</b>
<b>Picture #:</b>	<b>P000811.jpg</b>
<b>Depth:</b>	<b>&lt; 25 cm</b>

<b>Length:</b>	<b>NA</b>
<b>Width:</b>	<b>NA</b>
<b>Thickness:</b>	<b>NA</b>
<b>Weight:</b>	<b>NA</b>

## Appendix D – Transect Data

### EMPIRE RANGE

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth (meters)	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
A1	30.00	252	649634	994520	1	6.8	20	<1	<25cm	mag. rock	NA	10.16x5.08x1.2	350
A2	40.00	252			none	-	-	-	-	-	-	-	-
A3	44.80	252			none	-	-	-	-	-	-	-	-
A4	44.97	256			none	-	-	-	-	-	-	-	-
A5	94.00	256			none	-	-	-	-	-	-	-	-
A6	64.49	254			none	-	-	-	-	-	-	-	-
A7	33.00	252			none	-	-	-	-	-	-	-	-
B1	70.00	362	653315	994179	none	-	-	-	-	-	-	-	-
B2	100.00	362	-	-	1	68	70	<1	<25cm	mag. rock	NA	-	-
B3	100.00	362	-	-	none	-	-	-	-	-	-	-	-
B4	70.00	362	-	-	1	37	150	<1	<25cm	mag. rock	NA	-	-
B5	45.17	360	-	-	none	-	-	-	-	-	-	-	-
B6	35.08	312	-	-	none	-	-	-	-	-	-	-	-
B7	60.45	334	-	-	none	-	-	-	-	-	-	-	-
B8	22.07	334	-	-	none	-	-	-	-	-	-	-	-
B9	21.42	334	-	-	none	-	-	-	-	-	-	-	-
B10	138.56	NA	-	-	none	-	-	-	-	-	-	-	-
B11	80.00	NA	-	-	none	-	-	-	-	-	-	-	-
C1	100.00	15	645582	997482	1	2	15	<1	<25cm	mag. rock	NA	-	-
			-	-	2	6.4	30	<1	<25cm	mag. rock	NA	-	-
			-	-	3	27.5	25	<1	<25cm	mag. rock	NA	-	-
			-	-	4	56.5	30	<1	<25cm	mag. rock	NA	-	-

UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Pina and Balboa West Ranges

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
			-	-	5	71	150	<5	<25cm	BDU33	P000817	NA	NA
			-	-	6	74.5	70	<1	<25cm	frag	P000818	NA	NA
			-	-	7	76.5	170	<5	<25cm	mag. rock	NA		
			-	-	8	81.8	240	<5	<25cm	mag. rock	NA		
			-	-	9	87.5	70	<1	<25cm	frag, pipe, 2 23 ammo	P000819	20.32x12.7x1.2 7	1247.36
			-	-						frag, pipe, 2 23 ammo	P000819	21.59x2.54x2.5 4	354.36
			-	-	10	95.5	130	<1	<25cm	frag	P000831	NA	NA
C2	100.00	15	-	-	1	17	60	<1	<25cm	nails, cart. links	P000815	8.26x.95x.95	14.18
			-	-	2	23	135	<5	<25cm	frag	P000835	12.07x13.34x.6 4	283.49
			-	-	3	29	30	<1	<25cm	fuze component	P000814	10.16x5.08x5.0 8	184.27
			-	-	4	30.8	30	<1	<25cm	grenade spoon	P000813	12.7x1.27x.16	14.18
			-	-	5	37	70	<1	<25cm	mag. rock	NA		
			-	-	6	56.5	25	<1	<25cm	frag, belt clip	P000812	NA	NA
			-	-	7	89	155	<5	<25cm	frag	P000820	12.7x6.35x2.22	498.94
			-	-	8	95	30	<1	<25cm	rock, pipe	P000821	35.56x2.54x2.5 4	544.3
			-	-	9	20	Mk 29	?	<25cm	frag	P000834	5.08x13.97x.95 3	240.97
C3	27.37	52	-	-	1	3.7	25	<1	<25cm	frag	P000807	12.7x5.08x.64	212.62
			-	-	2	18	50	<1	<25cm	mag. rock	NA		
C4	40.47	53.53	-	-	1	1.5	130	<5	<25cm	3.5" motor	P000797	26.67x8.89x8.8 9	1700.94
			-	-	2	16	50	<1	<25cm	mag. rock	NA		
			-	-	3	22.5	70	<1	<25cm	81mm fuze comp.	P000808	NA	680.38
			-	-	4	26.7	180	<5	<25cm	mag. rock	P000796	NA	NA
			-	-	5	31	20	<1	<25cm	mag. rock	NA		
			-	-	6	34.3	100	surface	<25cm	frag (3 pieces)	P000797	17.78x5.4x.95	425.24
											P000797	7.62x5.08x1.27	240.97
											P000797	10.16x3.81x.95	170.09
C5	47.69	49.23	-	-	1	4.3	100	surface	<25cm	mag. rock	P000798	NA	NA

*UXO Site Investigation for  
U.S. Military Ranges in Panama:  
Empire, Balboa West and Piña Ranges*

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
			Easting	Northing									
			-	-	2	22.5	20	<1	<25cm	electric terminals	P000799	NA	NA
			-	-	3	27	80	surface	<25cm	reinforc. concrete	P000800	NA	NA
			-	-	4	38	190	<.5	<25cm	flare holder, rock s	P000801	8.89x6.35x5.72	141.75
			-	-	5	40.8	100	<.5	<25cm	wire	P000802	60.96x48x.48	113.4
			-	-	6	44	25	<1	<25cm	wire	NA	NA	63.79
			-	-	7	46	>200		<25cm	bunker	NA		
C6	41.13	52.22	-	-	1	9.3	60	<1	<25cm	frag	NA	NA	NA
			-	-	2	13.8	NA	NA	<25cm	frag	P000803	NA	NA
			-	-	3	18.3	50	<1	<25cm	wires, fuze	P000804	6.03x4.45x1.27	56.7
			-	-	4	33.7	40	<1	<25cm	frag	P000805	15.24x16.51x.64	765.42
C7	67.45	46	-	-	none	-	-	-	-	-	-	-	-
C8	32.53	46	-	-	1	15.5	110	<.5	<25cm	105mm baseplate	P000806	NA	NA
C9	37.82	47	-	-	none	-	-	-	-	-	-	-	-
C10	24.79	55	-	-	none	-	-	-	-	-	-	-	-
C11	47.17	50	-	-	none	-	-	-	-	-	-	-	-
C12	46.02	66.12	-	-	none	-	-	-	-	-	-	-	-
C13	43.49	66	-	-	none	-	-	-	-	-	-	-	-
C14	61.39	31.48	-	-	1	41.2	20	<1	<25cm	mag. rock			
			-	-	2	48.3	50	<1	<25cm	mag. rock			
C15	52.69	31.55	-	-	none	-	-	-	-	-	-	-	-
C16	35.50	72.03	-	-	1	21	30	<.5	<25cm	mag. rock			
C17	116.67	72.03	-	-	1	73.7	20	<.5	<25cm	mag. rock			
C18	12.90	101	-	-	1	7	70	<1	<25cm	frag	NA		
C19	22.61	71.24	-	-	none	-	-	-	-	-	-	-	-
C20	108.43	50.42	-	-	1	93.1	100	<.5	<25cm	mag. rock			
C21	63.78	64.26	-	-	1	35.5	200	surface	<25cm	flare	NA		
D1	64.47	78	-	-	1	22	25	<1	<25cm	geologic			
			-	-	2	26.6	20	<1	<25cm	geologic			

UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Pina and Balboa West Ranges

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
			Easting	Northing									
			-	-	3	38.8	20	<1	<25cm	geologic			
			-	-	4	41	40	<1	<25cm	no reading			
			-	-	5	46	40	<1	<25cm	mag. rock			
			-	-	6	56	>20	<1	<25cm	mag. rock			
D2	44.06	89.25	648673	995639	1	2	50	<1	<25cm	frag	NA		
D3	39.39	81.08	-	-	none	-	-	-	-	-	-	-	-
D4	73.44	52.47	-	-	1	47.4	100	<1	<25cm	frag	NA		
D5	35.15	64.13	-	-	none	-	-	-	-	-	-	-	-
D6	46.80	59.23	-	-	1	32.8	>1000	<.25	<25cm	mag. rock			
D7	50.57	184.11	-	-	1	50	100	<1	<25cm	mag. rock			
D8	15.09	184.11	-	-	none	-	-	-	-	-	-	-	-
E1	56.33	123.23	645735	997184	1	49.3	150	<1	<25cm	frag	P000809	NA	NA
E2	70.62	120.19	-	-	1	7.6	160	<1	<25cm	frag	P000810	NA	NA
			-	-	2	21.3	80	<1	<25cm	mag. rock			
			-	-	3	24	160	<1	<25cm	mag. rock			
			-	-	4	32	500	surface	<25cm	metal scrap			
E3	49.01	120.08	-	-	1	15.6	1000	<1	<25cm	frag	P000811	NA	NA
			-	-	2	33.8	50	<1	<25cm	mag. rock			
			-	-	3	34.6	50	<1		no reading			
			-	-	4	39.7	50	<1	<25cm	mag. rock			
			-	-	5	45.4	35	<1	<25cm	mag. rock			
E4	33.57	110.29	-	-	none	-	-	-	-	-	-	-	-
E5	48.25	112.13	-	-	1	6.8	50	<1		mag. rock			
E6	86.47	64.22	-	-	none	-	-	-	-	-	-	-	-
E7	46.47	75.16	-	-	1	1.5	40	<1	<25cm	mag. rock			
E8	110.73	91.26	-	-	1	78.7	80	<1	<25cm	mag. rock			
			-	-	2	83.4	25	<1	<25cm	mag. rock			
			-	-	3	85.7	25	<1	<25cm	mag. rock			
Bayonet										2.75" rocket head	P000836	NA	NA

BALBOA WEST RANGE

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
F1	74.26	87.53	640568	998528	1	12.2	130	<1	<25cm	cart. links	P000783	NA	NA
			-	-	2	14.9	100	<1	<25cm	.223 cases	P000784	NA	NA
			-	-	3	17.1	200	<1	<25cm	.223 blanks	P000785	NA	NA
F2	93.26	90.81	-	-	1	26.9	30	<1	<25cm	no reading	-	-	-
F3	93.47	93.1	-	-	none	-	-	-	-	-	-	-	-
F4	100.18	93	-	-	none	-	-	-	-	-	-	-	-
F5	20.3	131	-	-	none	-	-	-	-	-	-	-	-
F6	40.43	108.13	-	-	none	-	-	-	-	-	-	-	-
F7	59.55	74.41	-	-	none	-	-	-	-	-	-	-	-
F8	20.61	78.18	-	-	none	-	-	-	-	-	-	-	-
F9	64.86	77.48	-	-	none	-	-	-	-	-	-	-	-
F10	64.02	107.5	-	-	none	-	-	-	-	-	-	-	-
F11	45.67	41.22	-	-	none	-	-	-	-	-	-	-	-
F12	39.43	319	-	-	none	-	-	-	-	-	-	-	-
F13	42.63	294.15	-	-	none	-	-	-	-	-	-	-	-
F14	53.16	337.33	-	-	none	-	-	-	-	-	-	-	-
F15	46.78	1	-	-	none	-	-	-	-	-	-	-	-
F16	76.15	62.45	-	-	none	-	-	-	-	-	-	-	-
F17	70.12	121	-	-	none	-	-	-	-	-	-	-	-
G1	79.53	91	640560	999800	none	-	-	-	-	-	-	-	-
G2	14.38	91	-	-	none	-	-	-	-	-	-	-	-
G3	37.04	73.41	-	-	none	-	-	-	-	-	-	-	-
G4	29.09	166.53	-	-	none	-	-	-	-	-	-	-	-
G5	64.4	172.11	-	-	none	-	-	-	-	-	-	-	-
G6	97.59	161.06	-	-	none	-	-	-	-	-	-	-	-
G7	44.39	67.47	-	-	none	-	-	-	-	-	-	-	-
G8	27.85	24.11	-	-	1	1.2	250	<5	<25cm	beer can	P000786	NA	NA
G9	30.25	24.11	-	-	none	-	-	-	-	-	-	-	-
G10	95.88	37.25	-	-	none	-	-	-	-	-	-	-	-

UXO Site Investigation For  
U.S. Military Ranges in Panama:  
Empire, Pina and Balboa West Ranges

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
			Easting	Northing									
H1	63.09	30.3	640407	1000403	1	56.1	20	<.5	dug 1 ft.	no reading	-	-	-
H2	42.42	59.33	-	-	none	-	-	-	-	-	-	-	-
H3	94.31	42.13	-	-	none	-	-	-	-	-	-	-	-
H4	131.12	58.12	-	-	1	16.5	20	<1	dug 1 ft.	no reading	-	-	-
			-	-	2	50.5	500	surface	<25cm	20mm link	P000788	8.26x7.62x3.18	42.52
			-	-	3	74	100	<1	<25cm	frag	P000789	10.16x3.18x.95	148.83
			-	-	4	80	100	<1	<25cm	frag	P000790	6.35x2.54x.95	-
H5	92.8	61.15	-	-	1	65	30	<1	dug 1 ft.	no reading	-	-	-
H6	33.8	64.53	-	-	none	-	-	-	-	-	-	-	-
H7	58.16	67.07	-	-	1	32	30	<1	dug 1 ft.	no reading	-	-	-
J1	118.18	305	640371	1000326	none								
J2	26.34	270	-	-	1	17.3	40	<1		20mm cart	P000791	10.16x3.18x3.18	113.4
J3	79.25	247	-	-	1	8	12	<1		mag. rock	-	-	-
J4	27.79	262.31	-	-	none	-	-	-	-	-	-	-	-
J5	109.04	271	-	-	none	-	-	-	-	-	-	-	-
J6	56.87	271	-	-	none	-	-	-	-	-	-	-	-
J7	56.06	278	-	-	none	-	-	-	-	-	-	-	-
J8	31.73	278	-	-	1	29.2	30	<1		20mm,clip	P000792	NA	85.05
J9	54.86	276	-	-	1	23	125	<1		2.75" rocket fin	P000795	15.24x3.18x.32	42.52
K1													
K2													
K3													
K4													
K5													
K6													
K7													

PINA RANGE

Transect	Distance (meters)	Compass Heading (deg.)	GPS Coordinates (WGS 84, UTM, Zone 17)		Anomaly Number	Distance from transect origin (meters)	Anomaly Magnitude (EM61HH) (mV)	Estimated Depth (meters)	Actual Depth	Actual Anomaly	Picture ID	Dimensions (HxWxD cm)	Weight (grams)
			Easting	Northing									
L1	117.25	256.28	615033	1021490	1	33.2	620	<.25	<25cm	milk crate	P000745	39.37x33.02x29.85	>2.2 kg
L2	80.47	272.74	-	-	none	-	-	-	-	-	-	-	-
L3	62.42	294.21	-	-	none	-	-	-	-	-	-	-	-
L4	56.15	210.36	-	-	none	-	-	-	-	-	-	-	-
L5	112.18	188.44	-	-	none	-	-	-	-	-	-	-	-
L6	61.37	200.41	-	-	none	-	-	-	-	-	-	-	-
L7	88.56	224.35	-	-	none	-	-	-	-	-	-	-	-
M1 (@L5)	66.21	243.19	-	-	none	-	-	-	-	-	-	-	-
M2	64.64	259.5	-	-	1	49	350	<.25	<25cm	M16 mag.	P000746	NA	NA
M3	144.63	288.17	-	-	none	-	-	-	-	-	-	-	-
N1	75.76	302.5	614687	1018735	1	5.5	70	<1	<25cm	beer can			
N2	77.55	311.23	-	-	2	13.2	500	<1	<25cm	barbed wire			
N3	56.56	310.25	-	-	1	67.2	300	surface	<25cm	40mm Prac.	NA		
N4	134.76	298.29	-	-	none	-	-	-	-	-	-	-	-
N5	36.45	320.13	-	-	none	-	-	-	-	-	-	-	-
N6	68.1	347.11	-	-	1	60.6	20	<.5	-	no reading			
N7	44.58	339.42	-	-	none	-	-	-	-	-	-	-	-
N8	60.36	306.07	-	-	none	-	-	-	-	-	-	-	-
N9	28.74	255.25	-	-	none	-	-	-	-	-	-	-	-
N10	31.08	270.06	-	-	none	-	-	-	-	-	-	-	-
N11	31.05	320.24	-	-	none	-	-	-	-	-	-	-	-
N12	41.9	285	-	-	none	-	-	-	-	-	-	-	-
N13	103.23	304	-	-	none	-	-	-	-	-	-	-	-

*Empire, Pina and Balboa West Ranges*

[illegible]

## **Appendix E – Acronym List**

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ACE	-	Army Corps of Engineers
AEC	-	Army Environmental Center
AF	-	Air Force
AFB	-	Air Force Base
AOC	-	Area of Concern
ATD	-	Advanced Technology Demonstration
ATD	-	Advanced Technology Division
bgs	-	Blow Ground Surface
CAN	-	Canister
DDESB	-	Department of Defense Explosive Safety Board
DoD	-	Department of Defense
EM	-	Electromagnetic
EOD	-	Explosive Ordnance Disposal
FAR	-	False Alarm Rate
FUDS	-	Formerly Used Defense Site
GOP	-	Government of Panama
GPR	-	Ground Penetrating Radar
GPS	-	Global Positioning System
HE	-	High Explosive
HEAT	-	High Explosive Antitank
ICM	-	Improved Conventional Munitions
ICR	-	Installations Conditions Report
IR	-	Infrared
JPG	-	Jefferson Proving Grounds
LAW	-	Light Anti-Tank Weapon
LO	-	Live Ordnance

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NAVEODTECHDIV	-	Naval Explosive Ordnance Disposal Technology Division
OE	-	Ordnance and Explosive
OEW	-	Ordnance and Explosive Waste
OP	-	Observation Point
PCC	-	Panama Canal Commission
SCTI	-	Southern Command Center for Treaty Implementation
SI	-	Site Investigation
TIPA	-	Treaty Implementation Agency
TOW	-	Tube Launched Optically Tracked Wire Guided
TP	-	Target Practice
TT	-	Tactical Target
USACE	-	United States Army Corps of Engineers
USAEC	-	United States Army Environmental Center
USAEC	-	United States Army Environmental Center
USAF	-	United States Air Force
USARSO	-	United States Army South
UXO	-	Unexploded Ordnance